TRANSFER STATION MANUAL

REVISED AUGUST 1982

This report represents the independent findings, estimates and views of the consultants and not necessarily the policies and/or views of the government of Alberta except where specifically noted.

prepared by

Bissell & Associates Ltd.

in cooperation with
and sponsored by

Alberta
ENVIRONMENT

CONTENTS

PREFACE TO THE SECOND PRINTING I
PREFACE TO THE FIRST PRINTING II
INTRODUCTION III

SECTION 1 SOLID WASTE MANAGEMENT COMPONENTS
- 1.1 Storage 1
- 1.2 Collection 4
- 1.3 Transport 5
- 1.4 Disposal 7
- 1.4:1 Shredding 8
- 1.4:2 Baling 8

SECTION 2 RURAL COLLECTION/TRANSFER STATIONS
- 2.1 Introduction 9
- 2.2 Rural Collection System Options 10
- 2.2:1 Mail Box System 10
- 2.2:2 Green Box System 11
- 2.2:3 Drop Box System 17
- 2.2:4 Stationary Facilities 22
- 2.3 Planning 30
- 2.4 Regionalization 31

SECTION 3 URBAN TRANSFER STATIONS
- 3.1 Introduction 32
- 3.2 Direct Dump Versus Compaction Stations 34
- 3.3 Truck Transport 36

SECTION 4 TRANSFER STATION VS DIRECT HAUL
- 4.1 Introduction 44

SECTION 5 GLOSSARY OF TERMS
- 5.1 Definitions 51
- 5.2 Common Terminology 54
- 5.3 Conversion Data 55

LIST OF FIGURES

1	Example of Good Storage Practice	2
2	Direct Haul	6
3	Transfer Haul	6
4	Front End Loader	13
5	Rear End Loaders	14
6	Side Loaders	15
7	Common Containers Used in Green Box System	16
8	Typical Green Box Site	18
9	Typical Drop Box Site	18
10	Roll-Off Unit	19
11	Luggar Unit	20
12	Artist's Concept of Drop Box Site	21
13	Artist's Concept of Stationary Facility (Transtor)	23
14	Typical Compaction Type Stationary Facilities	24
15	Typical Stationary Compactor	25
16	Architectural Concept of a Bunker Stationary Facility	26
17	Typical Loading Equipment for a Bunker Facility	27
18	Typical Transfer Trailers	28
19	Architectural Concept of a Direct Dump Station	37
20	Architectural Concept of a Standard Transfer Building	38
21	Architectural Concept of a Standard Transfer Building	39
22	Architectural Concept of a Single Compactor Station	40
23	Architectural Concept of a Double Compactor Station	41
24	Architectural Concept of a Rural Direct Dump Site	42
25	Architectural Concept of a Push Pit Direct Dump Station	43

LIST OF TABLES

1	Storage Container Alternatives	3
2	Green Box System - Comparison By Vehicle Type	12
3	Comparison of Rural Systems	29
4	Urban Transfer Station Alternatives	35
5	Rated Capacity - Est. Loadings Common Refuse Units	45
6	Capital Recovery Factors	46
7	Estimated Costs to Own & Operate Mobile Equipment	47
8	Estimated Operating Costs of Refuse Units	48
9	Comparison of Haul Costs	49
10	Example of Service Area Size	50
11	Classification of Refuse Materials	52
12	Refuse Generation Guideline	53

PREFACE TO THE SECOND PRINTING

The first printing of the document "TRANSFER STATION MANUAL" was conducted in November 1979. This second printing, as well as the first edition, has been prepared with the cooperation and valuable assistance of the staff of Alberta Environment, Waste Management Branch, EDMONTON, Alberta.

It is our conviction that; the transfer of unwanted wastes from many communities, and the subsequent disposal of these materials in well operated sanitary landfills is a safe and superior alternative to the operation of numerous open dumps. Furthermore, in many cases where true operating costs of open dump operations are documented, closure of these small dumps and the transfer of wastes to regional landfills has proven to be the least cost solution.

Therefore, it is also our contention that now is the time we give the transfer of solid wastes a serious try, since the great majority of disposal facilities presently in operation throughout the Province cannot be considered sanitary landfills by any stretching of the definition.

Many new rural transfer sites have been constructed in the Province of Alberta since the first printing of the "Transfer Station Manual". Unfortunately, it often seems the only change from the old dump to the new transfer station location, has been the employment for sign painters at the new facilities. While this kind of action shows a thoughtful regard for public display, there is clearly more to a good transfer site than the readiness to promote the name.

As such we sincerely request that agencies considering the use of transfer facilities, follow a strict code in the control and operation of both urban and rural transfer sites. Within the Province extensive knowledge relating to control and operations of transfer facilities is available through Alberta Environment and the Department of Health.

August 1982

G. Bissell
BISSELL & ASSOCIATES LTD.

PREFACE TO THE FIRST PRINTING

This manual has been prepared by the consultants on behalf of, and, in cooperation with Alberta Environment. The primary objective is to provide specific subject information for municipalities committed to the implementation or upgrading of solid waste management practices within their communities. The publication contains a variety of engineering data and technical information relating to the transportation component of a total solid waste management system. The material presented has been developed from investigation of operable systems and several procedures still in the design and development stage. The majority of the material presented is not readily available, and to our knowledge, has never before been assembled into a single document.

Existing solid waste practices and systems vary widely in different locations of this country. Therefore, in most cases the presentation of one transfer method does not necessarily mean that all other methods are inadequate. Conversely, not all methods as presented in this publication are suitable for every area, due to variations in geography, populations, population distribution and other factors which dictate the use of transfer stations.

In many instances this manual speaks for the entire Alberta Solid Waste Management Field. It was prepared at the request of Alberta Environment, re-examined in general by the staff of this department, then reviewed and evaluated by the Head, Waste Management Branch, Alberta Environment. The input from both public and private refuse haulers throughout the Province has been significant.

Although the publication was not intended to cover the entire spectrum of the subject matter, it does include, wherever possible, the most important matters concerning the transfer of solid wastes. Additional information and facts pertinent to such matters, may be obtained by contacting Alberta Environment Waste Management Branch, EDMONTON, Alberta.

August 1979

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INTRODUCTION

All solid waste management systems are comprised of four elementary components, namely:

- STORAGE
- COLLECTION
- TRANSPORT
- DISPOSAL

These four primary components are closely interrelated and dependent on one another. The decisions made in each of these areas will dictate the cost, efficiency, safety and adequacy of the entire solid waste management system. For example, the effectiveness of the collection system and the cost of the operation depends to a great extent on the cooperation of the waste generator in providing proper storage containers and the subsequent placement of these containers in a suitable pickup location. (Figure 1) Conversely, the use of 45 gallon drums as a storage container contributes to the high injury rate experienced by refuse collection forces.

In recent years, the solid waste field has become a complex industry, secondary elements to the management of solid wastes have appeared. Transfer stations are a portion of a supplemental transportation segment to the fundamental system component referred to as "TRANSPORT".

The judgement as to the use of transfer facilities and supplemental transfer equipment will be guided considerably by, the length of the required haul and the time it takes to conduct the transporting of wastes from the collection districts to the final disposal site. Where the haul distances are very long, it may be necessary to use supplemental equipment without extensive further investigations. Generally, the type of equipment found to be most suitable on the collection routes will also be a major factor in any decision. In all cases, it must be remembered that planning for transfer facilities has to include existing collection activity as "Transport" and "Collection" are signficantly interconnected.

Although the manual presents relevant information regarding the system component of "TRANSPORT", it is essential that the reader understands the overall concept of the complete solid waste system. In this respect, brief descriptions are presented on all four system elements. To further assist the reader, a Glossary of Terms is presented in the last section of the document.

SECTION 1

SOLID WASTE MANAGEMENT COMPONENTS

1.1 STORAGE

The basis unit of the solid waste management system is the container used for the storage of refuse prior to the collection activity. This unit may be a standard garbage can at an individual residence, and/or a commercial type container normally found in the business area of a community. The container type used by the waste generator not only determines the speed, efficiency, cost of collection and esthetic appearance of the community, but also helps to control the occupational hazards associated with refuse collection.

Many municipalities have bylaws making the refuse generator responsible for the solid wastes they produce prior to the collection activity. At this point, ownership and control of the material also transfers. If the waste producer allows refuse to be scattered or dumped indiscriminately, the collection process becomes more difficult and expensive. Environmental pollution and public health hazards can also be created by irresponsible waste storage practices.

Creating of a code of practice, does not guarantee universal compliance. In fact, it is tremendously difficult to gain cooperation from all of the population. Tact, perserverance, patience, public education and vigilance are always needed and sometimes drastic enforcement methods are required.

However, the practices that may properly be required of refuse generators are on the whole neither complicated nor burdensome. From a public health standpoint, putrescible refuse must be stored in such a manner that disease vectors such as flies cannot have access to it, and that liquids cannot leak from the storage receptacles. For the prevention of nuisances, refuse of all kinds must be stored so that the wastes cannot be scattered by wind or animals, and accumulations are not unsightly. Finally, to achieve economical and effective collection it is essential that suitable containers of a proper size be provided. In addition, the containers should be kept or placed in locations which provide easy access to the collection forces.

The importance of suitable containers for the temporary storage of refuse both at residential and business locations cannot be overemphasized. Separation, draining or wrapping is of little value without adequate receptacles to protect the material until the collectors pick it up. It would seem logical, therefore, the public officials would emphasize citizen compliance with the regulations. Numerous reasons for the lack of enforcement have been advanced. One reason given is that elected officials are often unwilling to incur temporary public disfavor by supporting uniform enforcement of existing bylaws. The attitude is rather widely held, and it may easily be the real root of the difficulty.

In summary, it is evident that the preparation of refuse for collection assumes greater importance that is ordinarily realized. In fact it is one of the most significant factors in the whole problem of refuse collection and disposal.

FIGURE 1

Example of Good Storage Practice

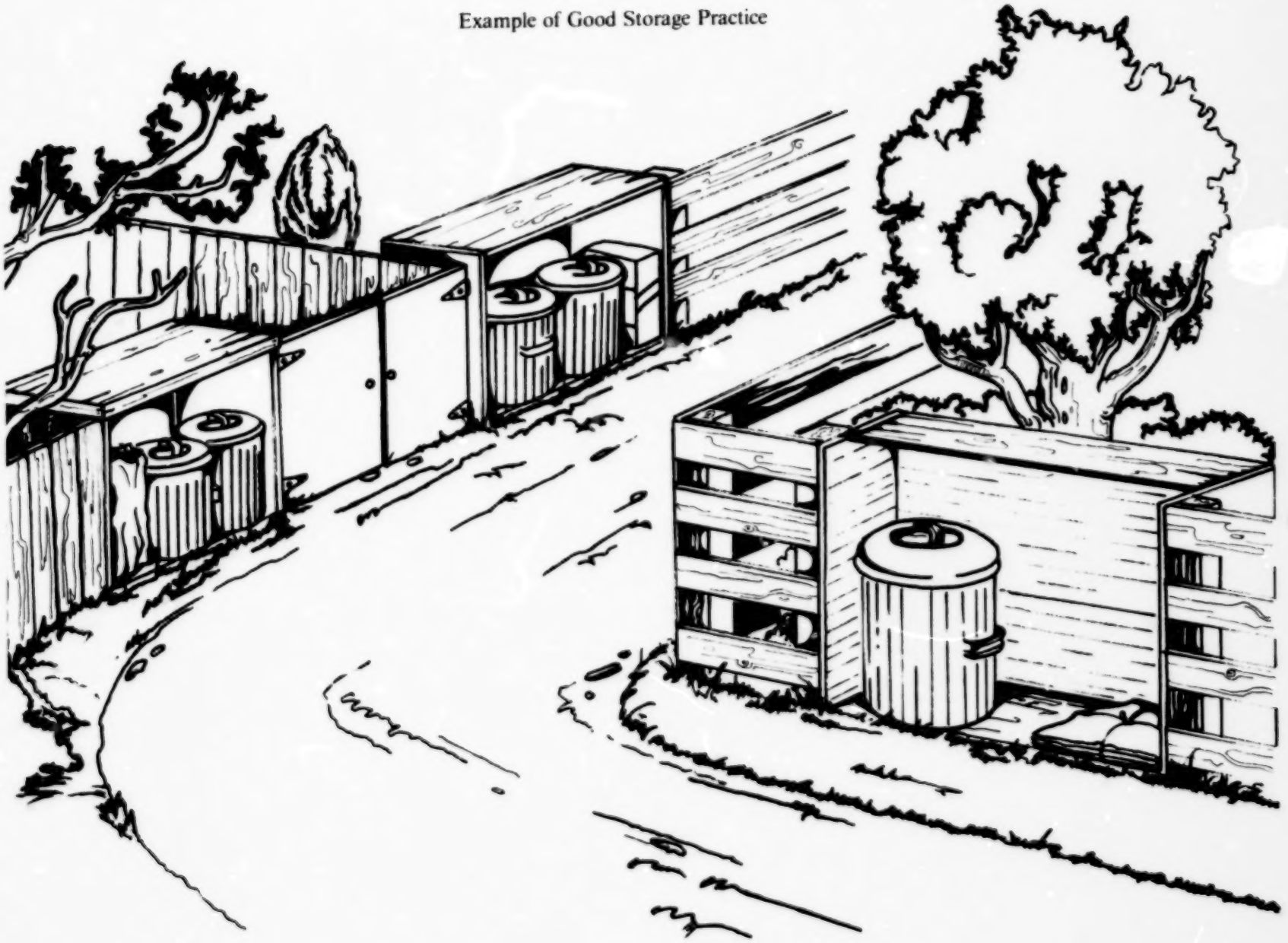


TABLE 1

STORAGE CONTAINER ALTERNATIVES

ALTERNATIVE	ADVANTAGES	DISADVANTAGES
Paper & Plastic Bags	- Handling ease - Less weight - Reduces litter problems in loading & unloading - Efficient, no return trip to point of origin - Promotes quickest pick-up - No odor when tied - Promotes safety to collection - Prevents fly entrance	- Cost of bag - Bags can tear easily when full or too thin - Susceptible to animal attacks - Not suited for bulky or sharp objects - Limited most for residential use
Metal or Plastic Garbage Cans	- Can be easily lifted - Is economical - Can accommodate plastic or paper bags	- Odors develop when not cleaned regularly - Asesthetically not attractive to curb side - Sometimes overloaded.
Drums (55 gals)	- None	- Lower collection efficiency - Difficult to handle - May result in injury (back & muscle strain) - Used for incineration, cinders and ash may cause hot loads in collection truck - Insect & rodent infestation due to lack of lids
Containers for Mechanized Collection	- More efficient, safe and sanitary than manual pick-up - Ideally suited for rural collection - Reduces collection costs	- Limited only to compactor vehicles - Limited in use to commercial and industrial places - Use in residential areas may cause opposition to container location
Stationary Storage Bins (boxes, etc.)	- None	- Requires manual emptying - Takes the greatest amount of time - Poses health hazard to the collection crew and public - Aesthetically not attractive - Promotes waste accumulations.

1.2 COLLECTION

The most costly part of a solid waste management system is the movement of wastes from the point of origin (storage location) to the collection vehicle. It is estimated that the collection activity alone accounts for approximately seventy percent of the total system costs. In the majority of cases the collection activity is conducted by either a public or private collection work force. However, in various communities and rural areas, this activity could be performed by the refuse generator, as an organized collection system may not be operable.

Collection systems can be classified in terms of the area they serve, namely urban or rural. The prime consideration in both systems is to provide either a total or partial collection service to the residential customer. Secondary, is the arrangement and provision for the collection of non-residential wastes. In small communities the collection system is easily combined from both sources without operational difficulty. In large urban areas, separate crews and collection systems are normally necessary to serve the non-residential customer.

Whether the complete removal of all refuse is necessary, however, depends to some extent on the size of the community and the relative density of its population. Very small municipalities may need little organized collection service, particularly where houses are far apart and businesses are neither large nor numerous. In some cases, it may be possible to bury the waste materials on individual properties, but this practice is discouraged in modern communities.

As communities become larger and people live closer together, however, it is increasingly unsatisfactory to burn refuse or to store it on individual properties. Also, it becomes more difficult for householders to get rid of their own rubbish and the nuisances caused by such individual disposal become more important. Gradually, organized service for the removal of all classes of refuse becomes essential, not only in the interests of protecting public health and avoiding nuisances, but also in the interest of over-all economy.

The importance of sound planning of refuse collection operations must not be underestimated. All too often, refuse administrators are content to layout collection systems and select methods and equipment by rules of thumb, guesses, estimates, or prejudiced opinions.

Sound planning involves a thorough analysis of all the factors that affect collection activity. These include a factual survey of the community refuse problem, the effects of the established methods, materials to be handled, the types of equipment available or selected, the physical layout of the area, factors affecting personnel practices, and the financial potential of the operating division.

The success of the administration of refuse collection systems depends in a large measure on the extent to which the many aspects of the problem are recognized and constructively handled. The overall task of managing collection services is a tremendous one, comparable to that of a large business enterprise. As such, it requires the serious attention of officials, administrators, personnel and citizens. Genuine desires to provide good service are considered to be of prime importance as there is no other service offered by a community which has so intimate a contact with individual citizens as refuse collection services.

1.3 TRANSPORT

The transporting of solid wastes from the collection route to a processing and/or final disposal site can occur in one of two fundamental ways:

- direct haul by the collection vehicle (Figure 2)
- use of transfer facilities and supplemental transportation (Figure 3)

In all cases, this phase of the solid waste system involves the movement of refuse from the collection area to the final disposal site. When the direct haul method is used, the location of the disposal site in relationship to the collection routes is a major factor in collection vehicle selection. A long haul distance and/or heavy traffic congestion can necessitate the use of large capacity collection units, while shorter transport hauls generally make the use of smaller collection units more ecnomical.

The management of solid wastes in areas where a collection service is not in place requires that the waste generator conduct the collection and transport components of the system. In this procedure, the transportation of refuse can be done by private vehicles such as: cars and/or light trucks. Generally, rural populations are faced with this task and provide their own direct haul to their local disposal sites.

It is not always feasible or economical, and sometimes it is not even possible to haul refuse (transport) in the collection vehicles to the disposal sites. The vehicles may be too small for efficient transportation or their travel time may be too great. In such situations, some kind of supplemental transportation is a necessary part of the system.

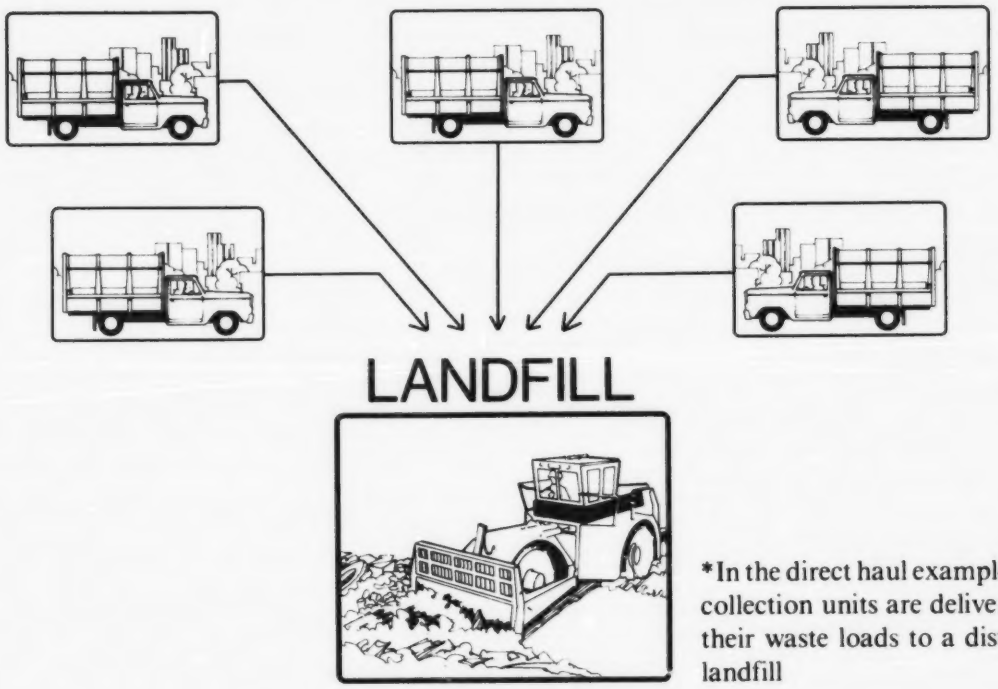
The basic concept of transfer facilities is that solid wastes are transferred from relatively small volume carriers such as collection vehicles, cars, light trucks etc., into high volume carriers which complete the transport of refuse to the final disposal site. As such, the use of transfer systems adds a secondary transportation item to the basic transport component.

There is little doubt that the use of transfer facilities adds a definite section to the transport cost of the total system. However, many municipal administrators and elected officials have been completely mislead by only looking at this individual component cost. Therefore, when analizing a total system cost and although the transport cost appears high as transfer costs are added to the transport segment, definite cost reductions for the other components are possible. For instance, the decreased mileage on collection vehicle travel when comparing short hauls to a nearby transfer station rather than a long haul to a distant disposal site will reduce the true collection costs. Likewise, transporting of wastes from greater distances, utilizing transfer equipment, increases the total waste load at a central sanitary landfill thereby reducing the cost per ton for disposal.

In comparing transport-transfer costs with direct haul costs, it must be recognized that the reduction and/or increase to costs throughout the total system have to be considered before any sound judgement can be rendered.

FIGURE 2

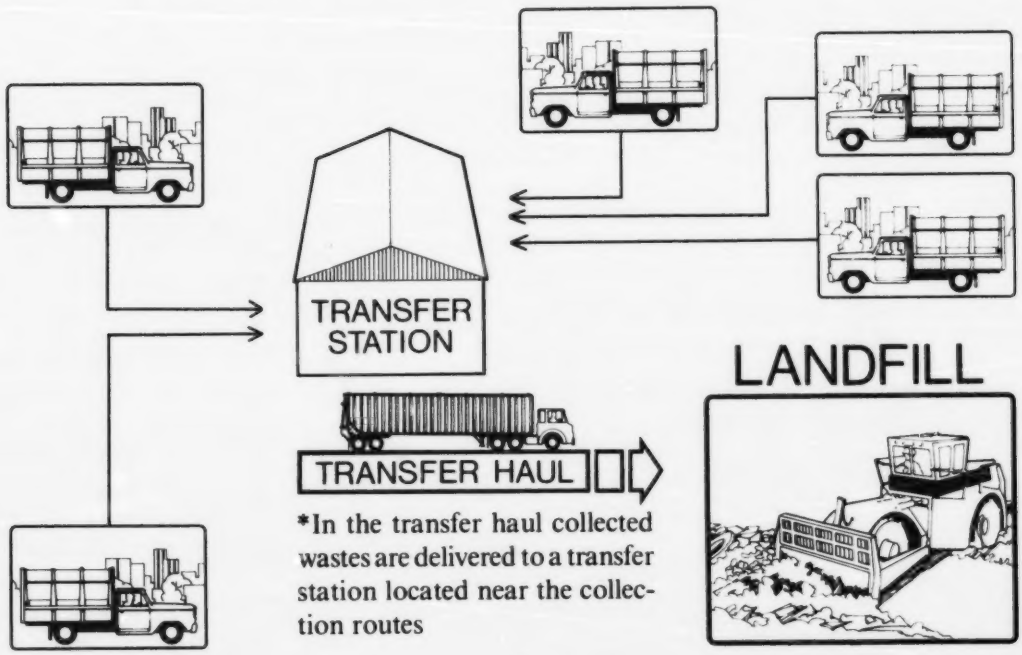
DIRECT HAUL



*In the direct haul example all collection units are delivering their waste loads to a distant landfill

FIGURE 3

TRANSFER HAUL



*In the transfer haul collected wastes are delivered to a transfer station located near the collection routes

1.4 DISPOSAL

The sanitary landfill method is the only practical alternative currently available in Alberta for complete disposal of solid wastes. Although a disposal technique, the open dump is regarded as an unsatisfactory and unacceptable method. Because of the known deficiencies and hazards of the open dump such as: air pollution due to burning refuse, and water pollution due to surface water or ground water contamination, governmental regulations throughout North America are geared towards their eventual elimination.

The responsibility for providing adequate refuse disposal service is presently handled in various ways within the Province. The municipal agencies may;

- have refuse disposed of at a site which is municipality owned and operated, or,
- the site is owned by the agency but the operations are conducted by private firms under a contract arrangement with the owner, and,
- the site may be privately owned and operated, but with government control over the operations.

Regardless of the manner in which the disposal site functions all solid waste disposal sites are under direct control of the Provincial Department of Health. Therefore, whether the site be privately owned or a municipal operation a standard operating procedure exists within the Province.

Associated with the essential components of disposal are a number of waste processing options. These options either utilize or convert the collected refuse into an energy source, and/or extract various materials for recycling or reuse. All are volume reduction techniques which still require proper sanitary landfill disposal of the residual and unuseable waste materials.

The principal processes of waste processing include:
incineration, composting, pyrolysis, and various mechanical, chemical and manual techniques for separation of materials. These processes are quite expensive and rely heavily on the availability of dependable markets for the recovered energy or materials to partially reduce the capital and operating process costs. Under present technologies, these processes also require large volumes of waste concentrated in a relatively small geographic area, in order that energy or material recovery will be cost-beneficial.

Within the total solid waste system the operating cost for disposal by sanitary landfilling generally remains constant on a daily basis. These same costs are not greatly influenced by the volume of waste arriving at an individual site. Therefore, when a particular site receives a small volume of waste the cost per ton for disposal will be higher than if the site received a higher volume.

Increasing the waste volumes at a central landfill thereby reducing the cost per ton for disposal is one of the principles of "REGIONALIZATION" which is covered in a later section of this manual.

1:4:1 SHREDDING

Since the early 1960's, two additional volume reduction techniques have gained extensive use in solid waste management programs. These procedures are commonly referred to as:

- Shredding
- Baling

Shredding is the process by which municipal solid wastes are mechanically reduced to a size which will facilitate ease of handling, storage and transport. The final product is relatively homogenous and of a significantly higher density. Shredding is a necessary first step in the pre-processing of the solid wastes for most material or energy recovery processes. It can also be used to increase the payloads of waste transfer vehicles and to increase operational efficiency in waste disposal by the sanitary landfill method.

THE CONDITIONS FAVORING SHREDDING ARE:

- [illegible] of available landfill space and high land costs may warrant a system of high volume reduction.
- Use for landfill facilities as a preliminary first step in an area where resource recovery is contemplated.
- Need to increase payloads or for more efficient transport, i.e. - as a substitute for compaction equipment.
- The use of cover material at the sanitary landfill site can be reduced in systems utilizing shredders.

1.4:2 BALING

Baling is also a volume reduction technique. In this method, the solid wastes are mechanically compacted into dense bales which may be strapped to retain their reduced size. High density balers are also available which do not require strapping. Shredding may precede baling to increase bale density and reduce equipment power and / or size requirements.

The baled solid wastes are hauled to a sanitary landfill for eventual burial. The baling equipment may be located relatively close to communities or even in residential areas from whence the bales could be trucked or rail-hauled to a distant disposal site. Balers have also been used in recyling and reclamation centers to facilitate high capacity transport of the recovered materials (Paper, textiles, metals, etc.) to a market outlet.

THE CONDITIONS FAVORING BALING ARE:

- Long hauls to disposal sites.
- Limited landfill space, long usage desired.
- Required or desired construction over a completed landfill.
- As an alternate to shredding (need to reduce noise, municipal or provincial constraints against use of shredders, zoning, etc.)
- Sufficient quantity of waste to promote full utilization of equipment.
- Reduction of wind blown litter at landfill sites.

SECTION 2

RURAL COLLECTION/TRANSFER STATIONS

2.1 INTRODUCTION

Until very recently, solid waste management in the small population centers and surrounding rural areas was given a low priority. As a result, many inherent problems failed to be noticed relative to environmental protection. Historically, solid waste systems and practices in these areas has been independence of operation with minimal co-ordination among the population centers. Operating under the principal of home rule, each town, village and hamlet examined their solid waste handling problems and developed an individual course of action. The decisions made by these small population centers to maintain an independent operation has generally, produced solid waste systems that function inefficiently and unecomically. During this time the neighboring rural areas received very little attention in matters relating to solid waste management, other than the provision of a convenient dumping site.

In the past, disposal of refuse from rural areas has involved two main procedures:

- Dispose of the generated waste on one's own property.
- Direct haul the wastes to an open dump, usually located near a small population center within the rural resident's trading area.

In recent years throughout North America, considerable attention has been focused towards implementing solid waste systems which; can adequately manage the solid waste generated from the small communities and rural areas, without creating additional financial burden on the waste generator. Such systems provide these areas with a viable method to:

- Abandon the unsightly open dump.
- Provide a higher level of service to the resident.
- Reduce present solid waste operating costs.

These same systems offer the waste producer two additional alternatives to those previously mentioned for solid waste management in rural areas, namely:

- Participate in a house-to-house collection service, commonly known as the "mail box" system.
- Haul their generated wastes to a centrally located intermediate storage area. Storage areas may take the form of facilities widely referred to as "green-box", "drop-box" or "stationary facility" systems. These storage areas are the first phase of a rural transfer system.

Since the development of these systems, the solid waste planner now has an extensive list of available alternatives from which to plan and implement an efficient, economical solid waste management program. The major factors limiting the use of such options to a specific service are:

- The experience, vision and resourcefulness of the solid waste planner.
- The ability of the specific service area to support the associated capital and operating costs of the selected system.
- The solid waste operating standards and service levels which are being demanded by the population.

It may appear that standards of public health and sanitation should not vary with community size. However, size does have an influence on solid waste management activities, particularly on the extent of service and the selection of methods. From a public health standpoint, the need for refuse collection is directly related to the population density.

Within the Province of Alberta various forms of rural waste collection are now in existence. The collection process has generally been of a contract nature whereby the rural resident is supplied a door-to-door service by a private hauler on a monthly fee basis. Conversely, most transfer and transport systems which now operate in the Province are owned and operated by municipal agencies.

The organization of collection services for a sparsely populated area is usually uneconomical. Economical viability can only occur in communities where the collection pick-ups are all located in one general area, or if independent population centers are grouped. This approach is discussed later under the heading of:

- REGIONALIZATION

2.2 RURAL COLLECTION SYSTEM OPTIONS

2.2:1 MAIL BOX SYSTEM

The "mail box" system provides for house-to-house collection in rural areas. Collection vehicles travel established rural postal delivery routes collecting household waste that has been placed adjacent to mailboxes. The system was developed under the assumption that:

- If a mail truck can travel a given route, a collection vehicle can travel the same route.
- Over the years the postal service has developed efficient routes for delivery in rural areas.
- Mailboxes have been placed on rural postal routes readily accessible to a driver, usually on the same side of the road, which aids in the collection process when related to solid wastes.

Under this system, residential generators that do not have postal mailbox service must agree with the collection agency on mutually acceptable collection pick-up locations. The "mail box" system requires that collection days be designated in order for the residents to set-out their household refuse.

Compaction units, either rear end loaders and / or side loaders, with one or two man crews, have usually been utilized for this system.

The advantages of the "mail box" system is that it collects the largest percentage of generated household waste of any rural system and permits a high level of scheduled service to the rural resident and business enterprise. Finally, it provides a system whereby user charges can easily be established and collected from the individual waste generator based on waste volume collected.

The "mail box" system requires, however, that rural householders co-operate in setting out their containers at the roadside on the collection day. Containers sitting in their pick-up location are subject to being upset, plastic garbage bags can be torn and litter problems may occur. The operation is very time consuming, resulting in high collection costs in isolated rural areas. The expected level of participation by the rural resident is critical in developing the "mail box" system.

Within the Province, several organized "mail box" systems are presently in operation. The collection services are being conducted by various private haulers who are directly reimbursed by the individual residential user. The operable systems are normally found in the rural areas surrounding our larger urban centers. These systems currently provide a once per week or bi-monthly collection service to the waste generator. The collection pick-up is limited to normal household refuse. Materials such as bulky items (used appliances, etc.) are not collected, but rather hauled directly by the waste generator to either an open dump in the area and / or a sanitary landfill site near the major population center.

2.2:2 GREEN BOX SYSTEM

This system essentially involves the utilization of three to eight cubic yard metal containers with lids. The containers are placed at strategic locations on existing roadway shoulders and/or preconstructed turn-off areas adjacent to the rural road network. The site development varies, dependent on the vehicle type used in the overall system. In systems where the individual container is over forty-eight inches high, side loading doors or wooden steps are usually provided to assist the waste generator in dumping their refuse. The container provides a depository for normal household refuse generated by the rural residential population. These containers are emptied at their site locations by large capacity compaction units on a predetermined collection schedule. The collection system has generally utilized units referred to as:

- Front End Loaders (Figure 4)
- Rear End Loaders (Figure 5)
- Side Loaders (Figure 6)

Front end loaders are most commonly used for the "Green Box" system due mainly to their large capacity packer bodies, and their ability to dump larger volume containers. In addition, their dumping system allows the vehicle to approach the container head on without manually moving the container into the lifting position. Rear end and side loader units can accommodate the "Green Box" system, although at reduced efficiency, resulting in higher operating costs. The container size, when used with rear and side loader vehicles, is usually limited to the hopper capacity of the individual compactor body.

Although the "Green Box System" requires the least capital costs of the available container systems it displays proven operational disadvantages when used in rural areas. The major disadvantage is the system's inability to adequately contain the known refuse materials being generated within the rural areas which are larger than the container opening sizes. These materials which include such items as: fence posts with wire attached, large furniture, white goods and a multitude of demolition materials simply will not fit into the available green box container. As such, the waste generator either hauls these materials to the central sanitary landfill or merely drops the waste next to the container. Several systems of this type were instituted in Eastern Canada in the 1970's and have since been abandoned and/or changed to "drop-box" systems due to the previously mentioned problems. However, if it were possible to control the waste flow to only normal household garbage, the green box system would provide an adequate economical method.

TABLE 2

"GREEN BOX" SYSTEM

COMPARISON BY VEHICLE TYPE

ITEM	VEHICLE TYPE		
	Front Loading	Rear Loading	Side Loading
Normal Crew Size	- 1	- 2-3	- 2
Container Volume	- 2-8 cu. yd.	- 1-6 cu. yd.	- 1-4 cu. yd.
Packer Size	- 20-40 cu. yd.	- 16-30 cu. yd.	- 13-32 cu. yd.
Service Time/ Container	- 2 minutes	- 4 minutes	- 3 minutes
Site Maintenance	- Special crew	- Collection crew	- Collection crew
Type of Wastes	- Those fitting containers	- Those fitting rear hopper	- Those fitting through side doors
Vehicle Flexibility	- Restricted to front loading containers	- Rear loading container and house to house collection	- Side loading container and house to house collection
Container Site Development	- Pull off area from main road generally gravelled or paved surface	- Back-off area from main road generally gravelled or paved surface	- Road shoulder where vehicle can safely stop otherwise pull-off area from main road
Site Area/ Acres	- 0.6	- 0.6	- * 0.6
Gross Vehicle Weight	- 45,000-51,000	- 27,000-41,000	- 27,000-41,000
Vehicle Approach to Container for Dumping	- From front	- Backs into container	- Lifts container from side
Waste Size Limitation	- Yes	- Yes	- Yes

* denotes - if safe road shoulder area not available.

FIGURE 4

FRONT END LOADER
(commonly used in the Green Box System)

- Front end loaders usually carry a one man crew. The normal rated capacity is between 30-35 cu. yds. Packing of waste material is generally rated at 3:1

FIGURE 5
REAR END LOADERS
(commonly used in the Green Box System)

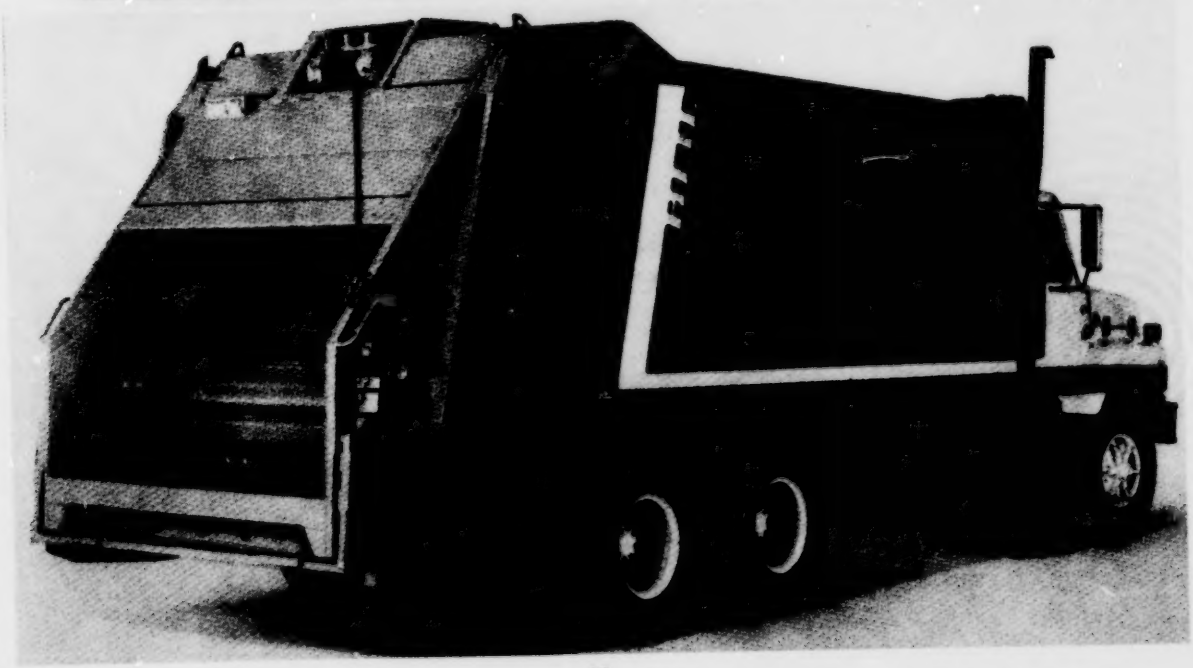
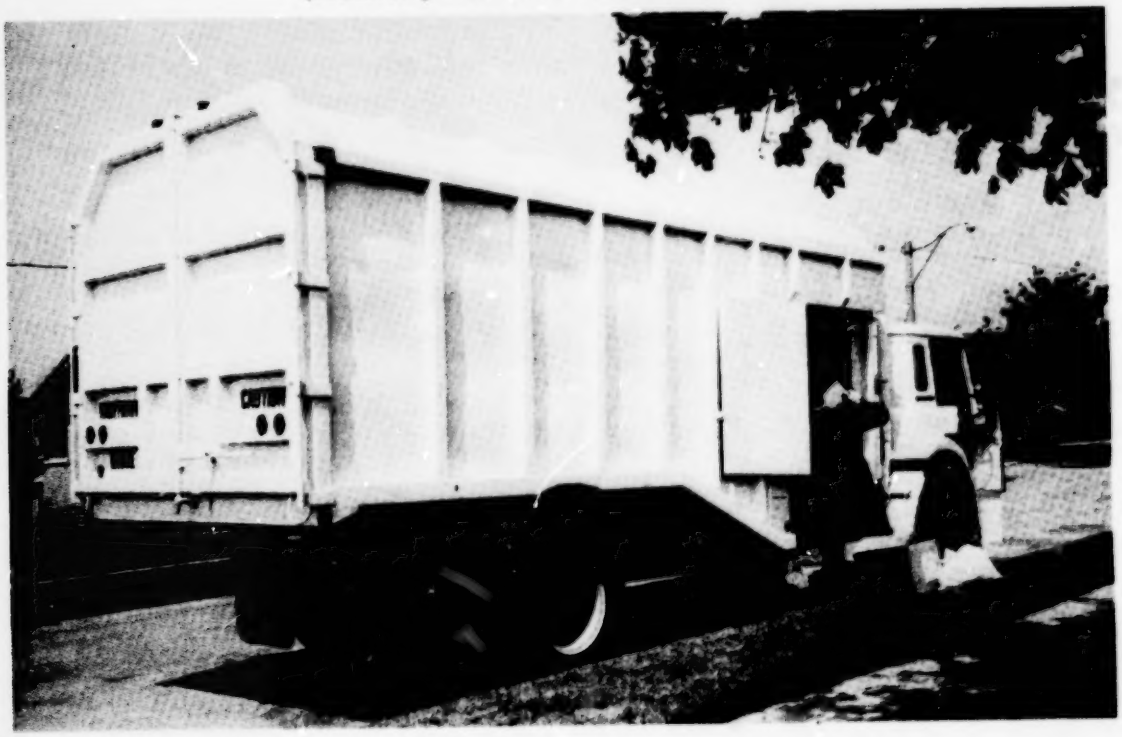


FIGURE 6

SIDE LOADERS
(commonly used in the Green Box System)



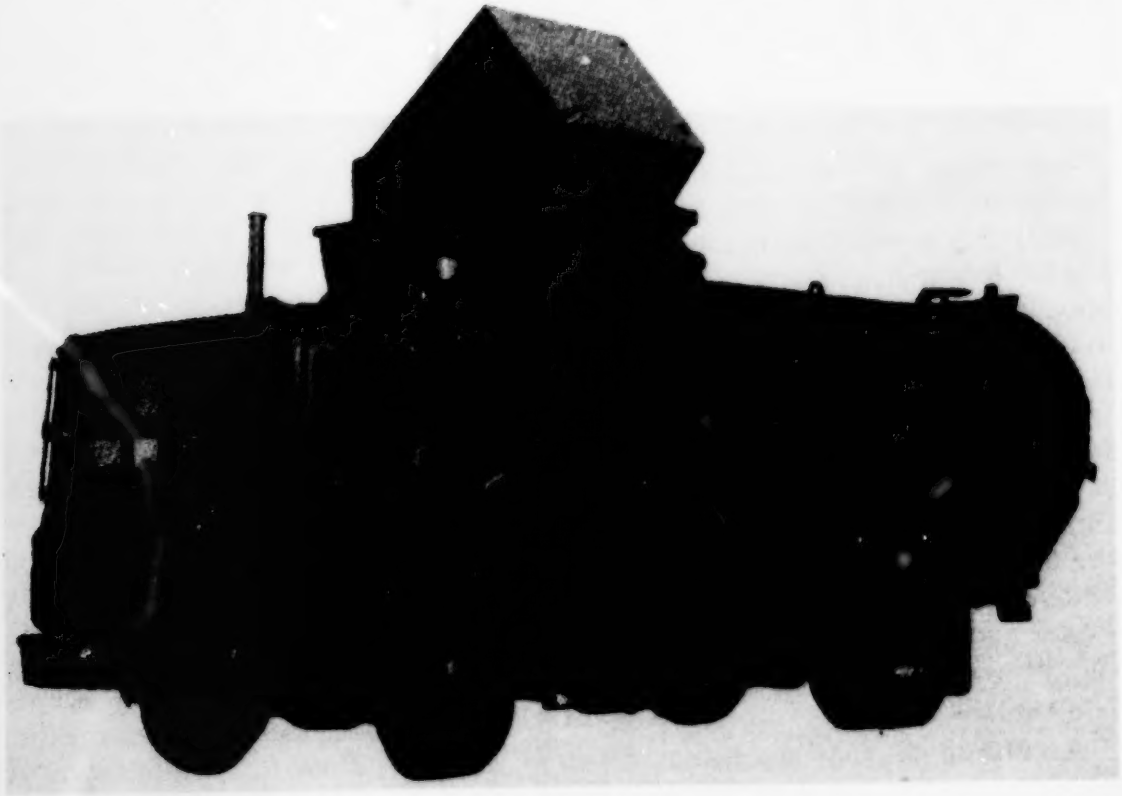
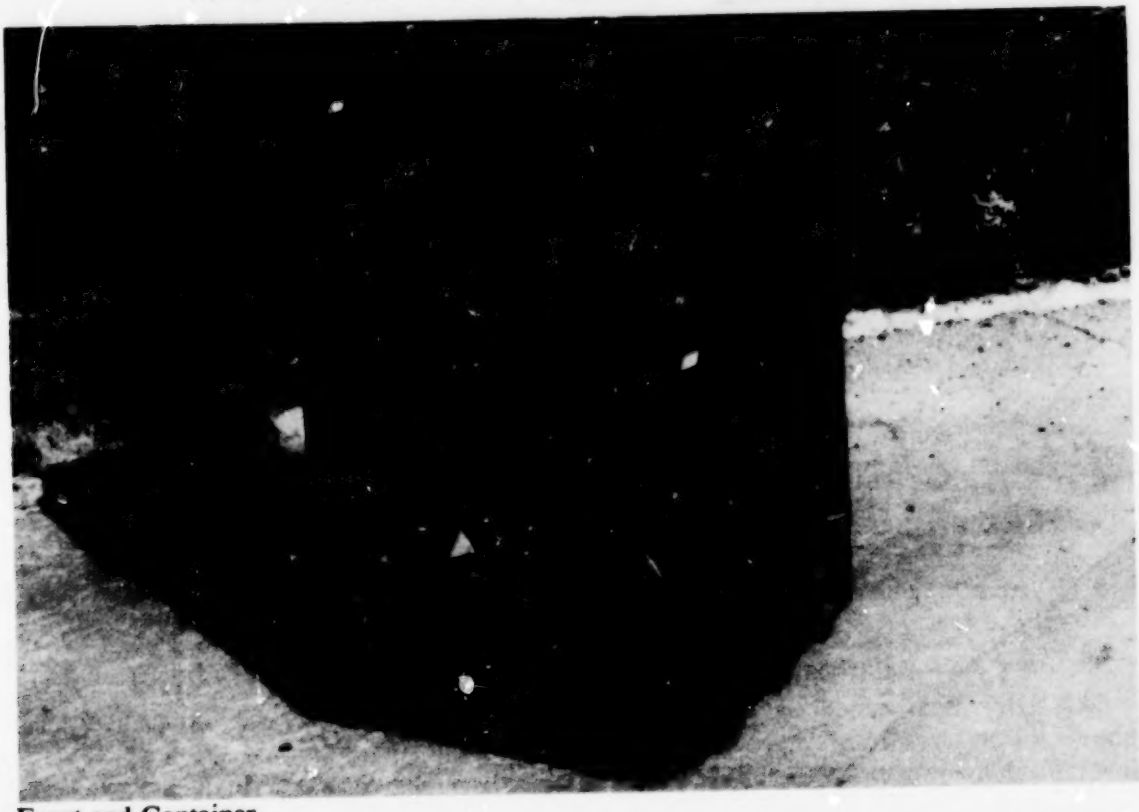
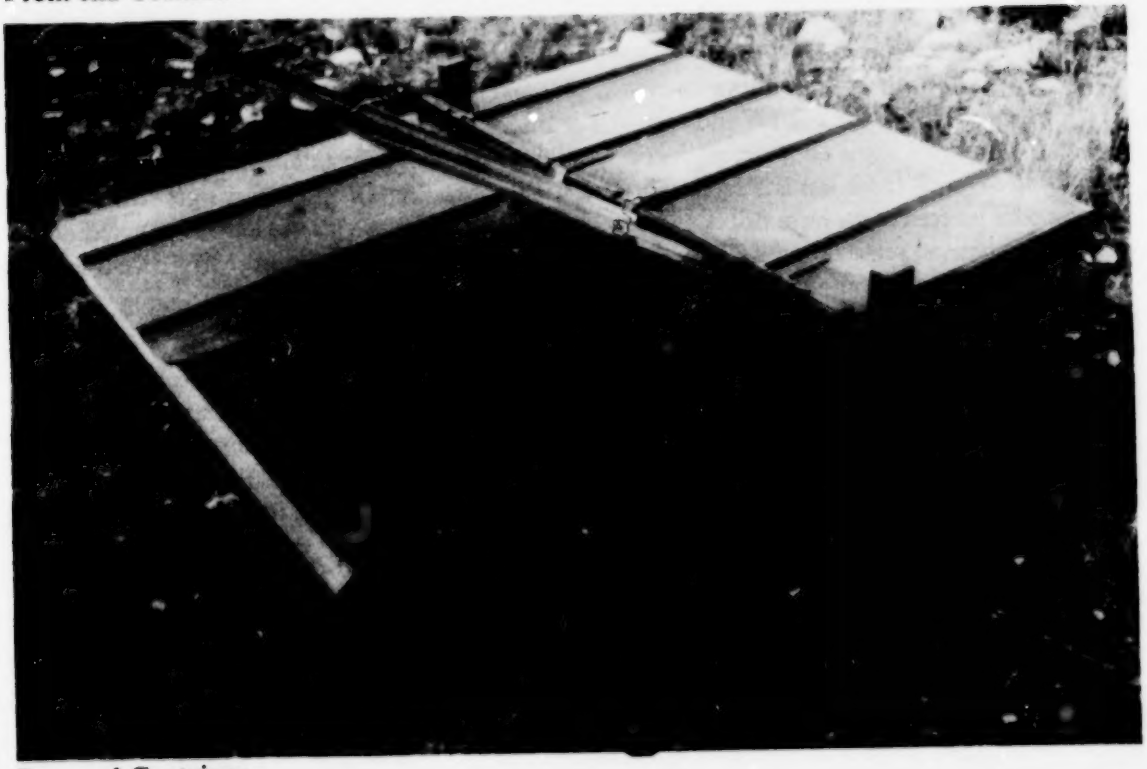


FIGURE 7

COMMON CONTAINERS USED IN GREEN BOX SYSTEM



Front end Container



Rear end Container

2.2:3 DROP BOX SYSTEM

The system allows for the use of a variety of container types, ranging in sizes up to fifty cubic yards. These containers are strategically located along highways or roads easily traversed by a collection vehicle. The individual resident or business establishment is required to deposit solid wastes in the container at the site location. The holding container provides an intermediate storage/disposal unit for the solid wastes generated by the surrounding population.

Full containers are replaced by an empty container under a set schedule and a predetermined routing system by the collection agency. The full containers are transported either singularly, by Roll-off and/or Luggar units, or in a series on flatbed trailers and trucks to the distant disposal site.

In the United States and in Canada, various vehicles are in general use serving the "Drop Box" system, namely;

- Roll-off (tilt frame) vehicles (Figure 10)
- Luggar trucks (Figure 11)
- Tilt Trailers pulled by truck units
- Crane systems mounted on flatbed trucks

The "Drop Box" system has been effectively employed in numerous rural areas and small population centers throughout North America. Public reaction to this system appears to be more favorable than towards the "Green Box" system, as the larger container is generally preferred. The major advantage of the large containers is their ability to readily accept a wide variety of materials, including white goods, bulky items and some demolition waste from the rural area.

This system does require a more extensive site development program, resulting in higher site development costs. In the roll-off and luggar containers, side walls up to eight feet high dictate the need for ramps to allow easy access to the container. With the installation of ramp areas, the unloading of small truck loads, such as half ton trucks, into the "Drop Box" is significantly easier than at sites where ramps have not been constructed. The site locations are usually selected on the basis of a common sense criteria. These sites should be located with due regard to where the waste producers reside, and, on main travel routes.

In the Province, the County of Flagstaff are one of the areas presently using the drop box system. The system has allowed the region to abandon eleven former open dumps and operate one regional sanitary landfill near Sedgewick, Alberta. Rural transfer sites were constructed near the major population centres within the area for use by both urban and rural residents. Roll-off units hauling 40 cu. yd. containers are utilized as the transport mode. Information regarding this system can be obtained by writing the County of Flagstaff, Sedgewick, Alberta.

It must be emphasized that although dimensions of a standard roll-off container are approximately eight feet wide by twenty-two feet long, little success has been found in discharging wastes from normal collection units into this container type. Therefore, in the majority of rural transfer systems presently in operation, collection vehicles utilized in the small population centres are required to direct haul to the final disposal site.

FIGURE 8

TYPICAL GREEN BOX SITE

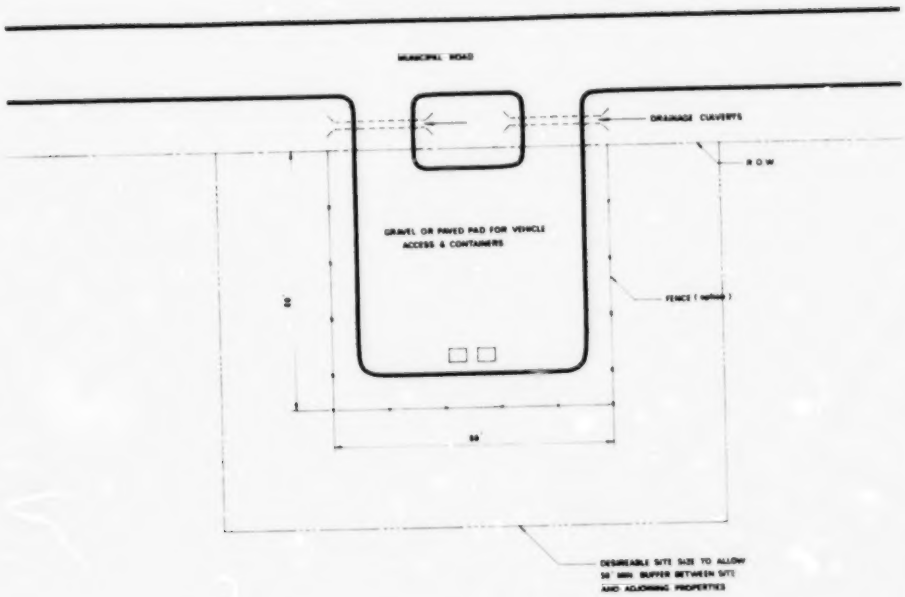

MUNICIPAL ROAD
DRAINAGE CULVERTS
R.O.W
GRAVEL OR PAVED PAD FOR VEHICLE ACCESS & CONTAINERS
FENCE (optional)
DESIREABLE SITE SIZE TO ALLOW 50 mtrs BUFFER BETWEEN SITE AND ADJOINING PROPERTIES

FIGURE 9

TYPICAL DROP BOX SITE

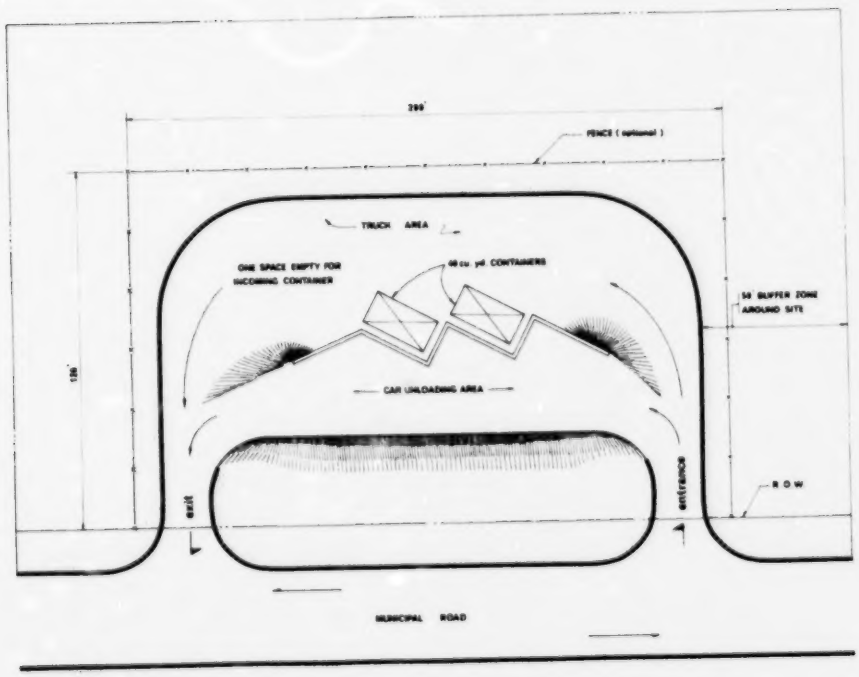


FIGURE 10

ROLL-OFF UNIT
(commonly used in the Drop Box System)

* The roll-off unit was initially developed to handle demolition - construction materials. The majority of drop box systems operating in rural areas use the roll-off units as the transport method for container movement from rural site to disposal facility. Up to a few years ago the units transported one container per trip. However, new developments in equipment allow the transporting of two containers per trip by attaching a tilt-frame pup trailer to the main truck.

FIGURE 11

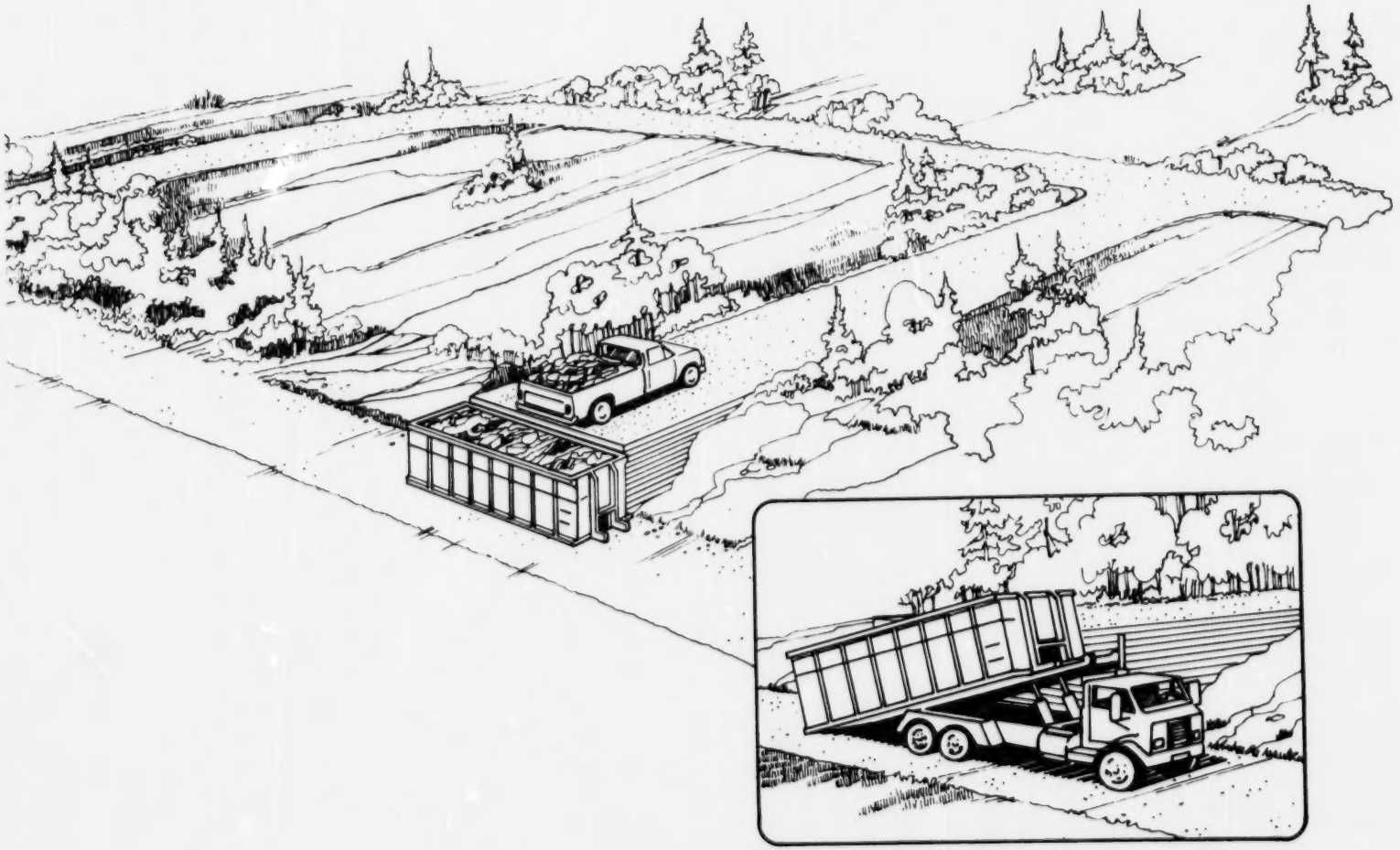
LUGGAR UNIT
(commonly used in the Drop Box System)

- Shown in the container dumping sequence

FIGURE 12

ARTIST'S CONCEPT OF DROP-BOX SITE

- Site depicted uses a single 50 cu. yd. roll-off container. The container is covered with a net type tarp during transport to prevent wind-blown litter. Some containers at existing sites have fixed wire mesh lids which are simply lowered to cover waste materials during the transport haul from the site to the sanitary landfill.



2.2:4 STATIONARY FACILITIES

The "Green Box" and "Drop Box" systems have limitations which affect the nature of material that they can normally handle. The size of items that can be deposited are proportional to the size of the bulk container being used. This generally compels the waste generator to haul "large bulky items" directly to a disposal site. These same systems are not adequate either in size or design to allow the direct dumping of larger loads into the storage unit by either collection vehicles and/or vehicles equipped with hydraulic hoisting equipment. Trucks carrying these loads usually direct haul the generated wastes to a disposal site, unless large "Drop Box" containers are in use.

During the last few years, various specialized refuse equipment manufacturers have developed systems geared towards supplying large capacity rural transfer systems. The equipment design and development has generally followed three methods;

- Stationary compactor sites where refuse can be deposited either manually or from all vehicles into a receiving container or trailer. The containers and/or trailers holding the compacted wastes are then transported to the final disposal site. (Figures 14 & 15)

- Large holding containers which accept refuse manually or directly from vehicles. The container simply acts as a temporary storage unit for the deposited refuse. The container is emptied in accordance with a predetermined schedule into a large capacity refuse trailer which then transports the load to a disposal site. (Figure 13)

- Holding bunkers similar in principle to silage pits where waste materials are deposited by collection units or the waste generator. These bunkers can be flat paved areas or concrete slabs with side walls. The wastes are then removed from these holding areas through the use of small lifting cranes (buckets) and placed in the proper transport unit for transport to the disposal location.

Regardless of the design variations of either the individual equipment, or the type of installation, the fundamental benefit of "Stationary Facilities" is the same, namely:

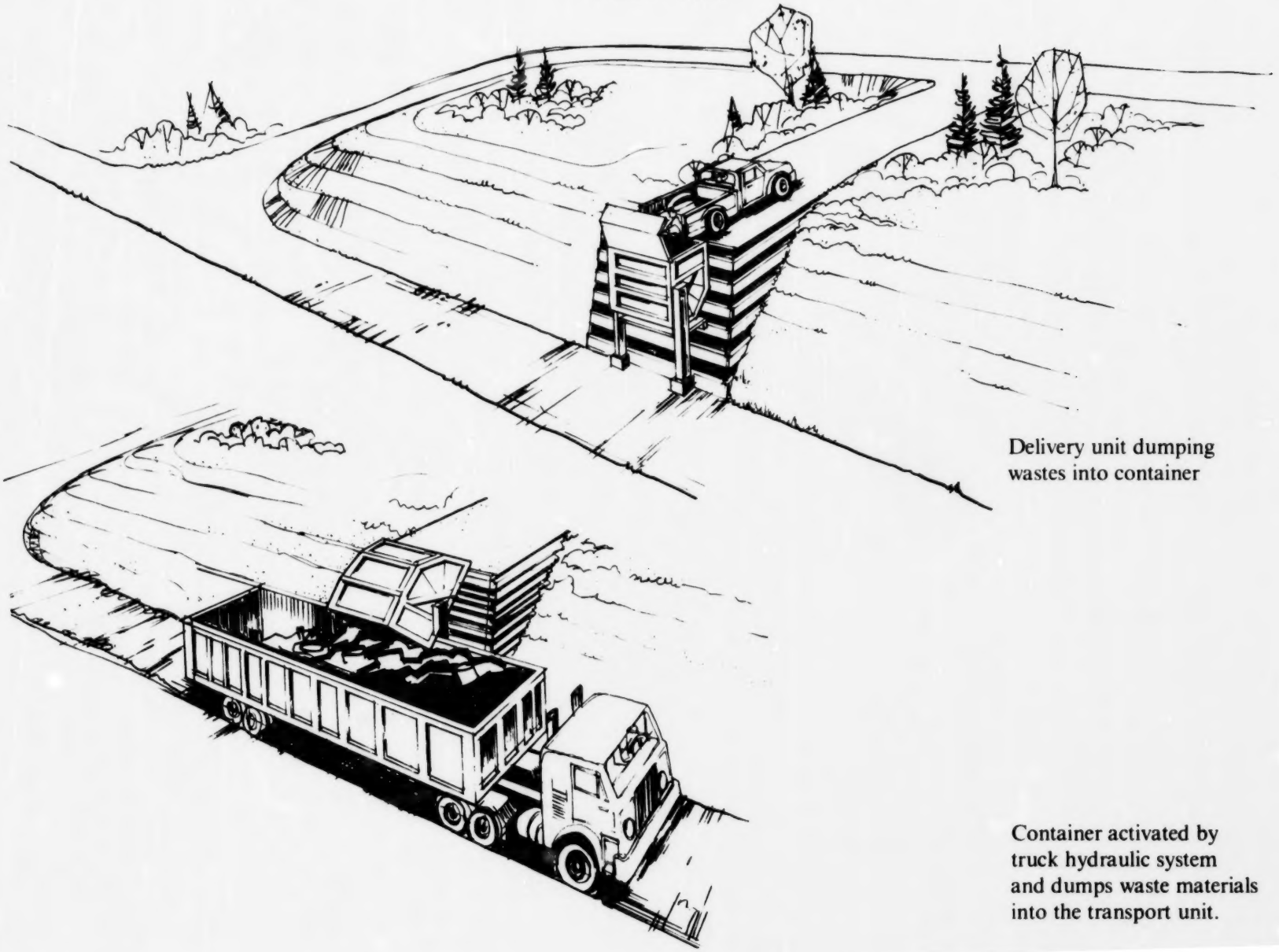
- "Stationary Facilities" offer a waste transfer site which can accept normal household refuse from all existing types of collection units. In addition, these facility types significantly increase the ability to accept other types of waste such as: bulky goods, white goods and minor demolition materials over all other rural container systems, and,

- The use of these facilities usually allows a greater haul distance to a distant landfill site, while at the same time, avoids imposing additional financial or logistical hardships on the individual resident or commercial establishment.

At the present time a system operates within the Drumheller Health Unit similar to Figure 13. This sytem covers an area of approximately 5000 square miles which is the largest geographic area in North America operating under one rural system. Operating costs per ton mile are presented in Table 5. Information regarding this system can be obtained by writing the Drumheller Solid Waste Association c/o City of Drumheller, Drumheller, Alberta.

FIGURE 13

ARTIST'S CONCEPT OF STATIONARY FACILITY
(Transtor Type)

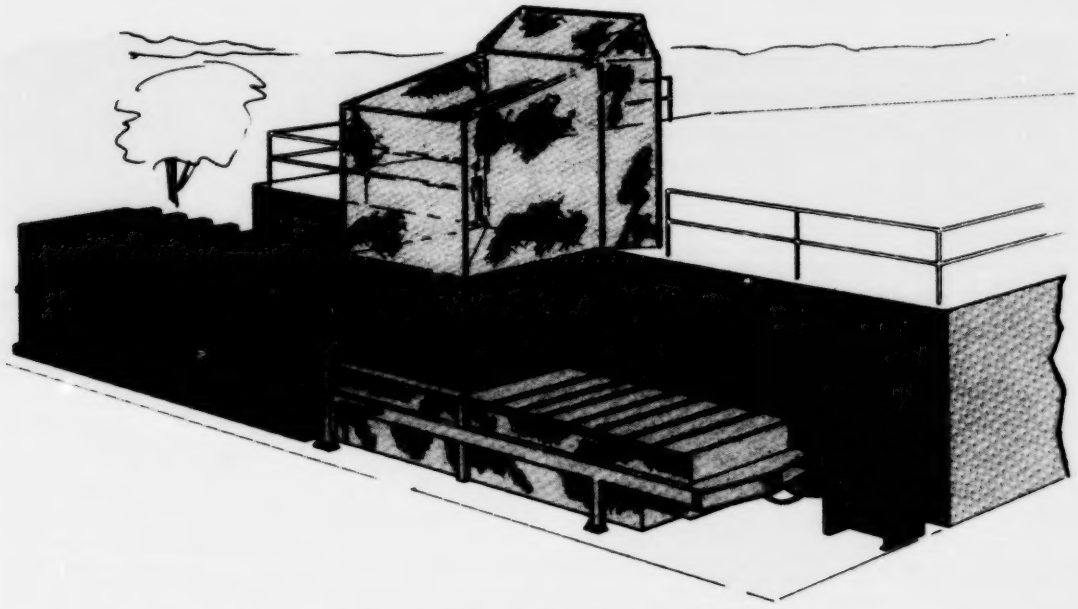


Delivery unit dumping wastes into container

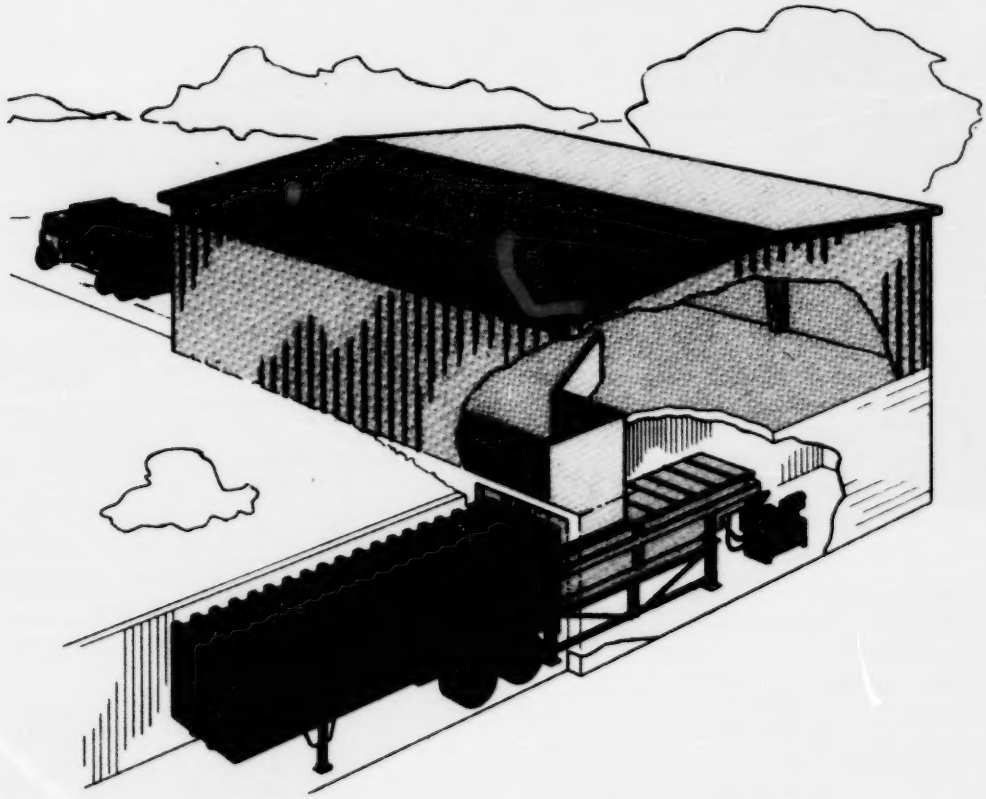
Container activated by truck hydraulic system and dumps waste materials into the transport unit.

FIGURE 14

TYPICAL COMPACTION TYPE STATIONARY FACILITIES



Typical Outdoor-Type Mini-Transfer Installation



Typical Mini-Transfer Installation in Building

FIGURE 15

TYPICAL STATIONARY COMPACTOR

Note: The depicted unit is a stationary compactor with a base rating of 2 cu. yds. which simply means that with each push of the hydraulic ram 2 yds. of waste materials are forced into the container. Compaction of the waste materials is accomplished inside the container as the volume of waste increases inside the container. The container shown is a standard roll-off compaction container which is securely attached to the compaction unit with hold-down cables, and/or turn buckles.

Waste materials are placed into the receiving hopper of the compactor. In some existing rural systems the compactor is activated by key, credit card and/or coin. Normal compaction ratio is approximately 6:1.

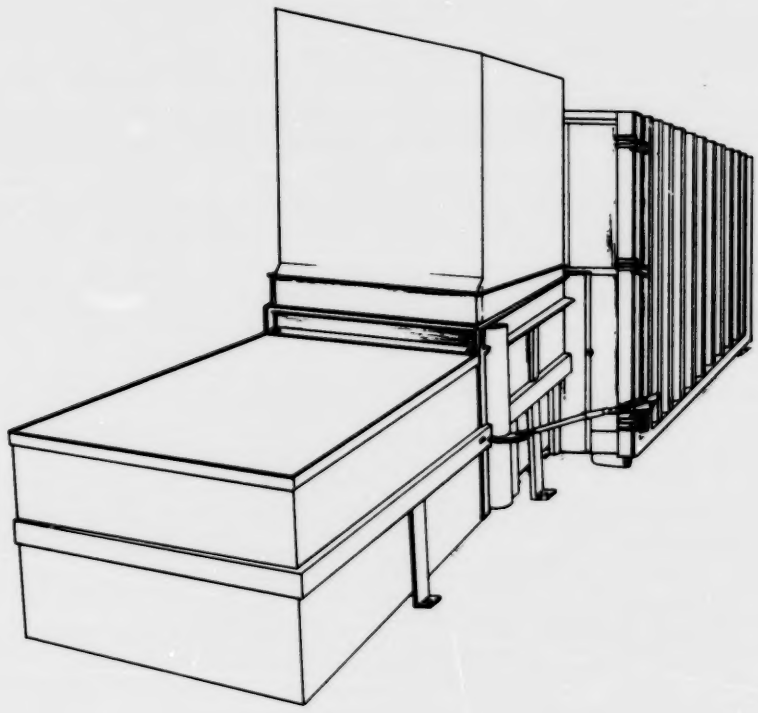


FIGURE 16

ARCHITECTURAL CONCEPT OF A BUNKER STATIONARY FACILITY

In this system, refuse is simply dumped within the concrete sidewalls of the structure. The lifting bucket (shell) loads and distributes wastes into the transport unit.

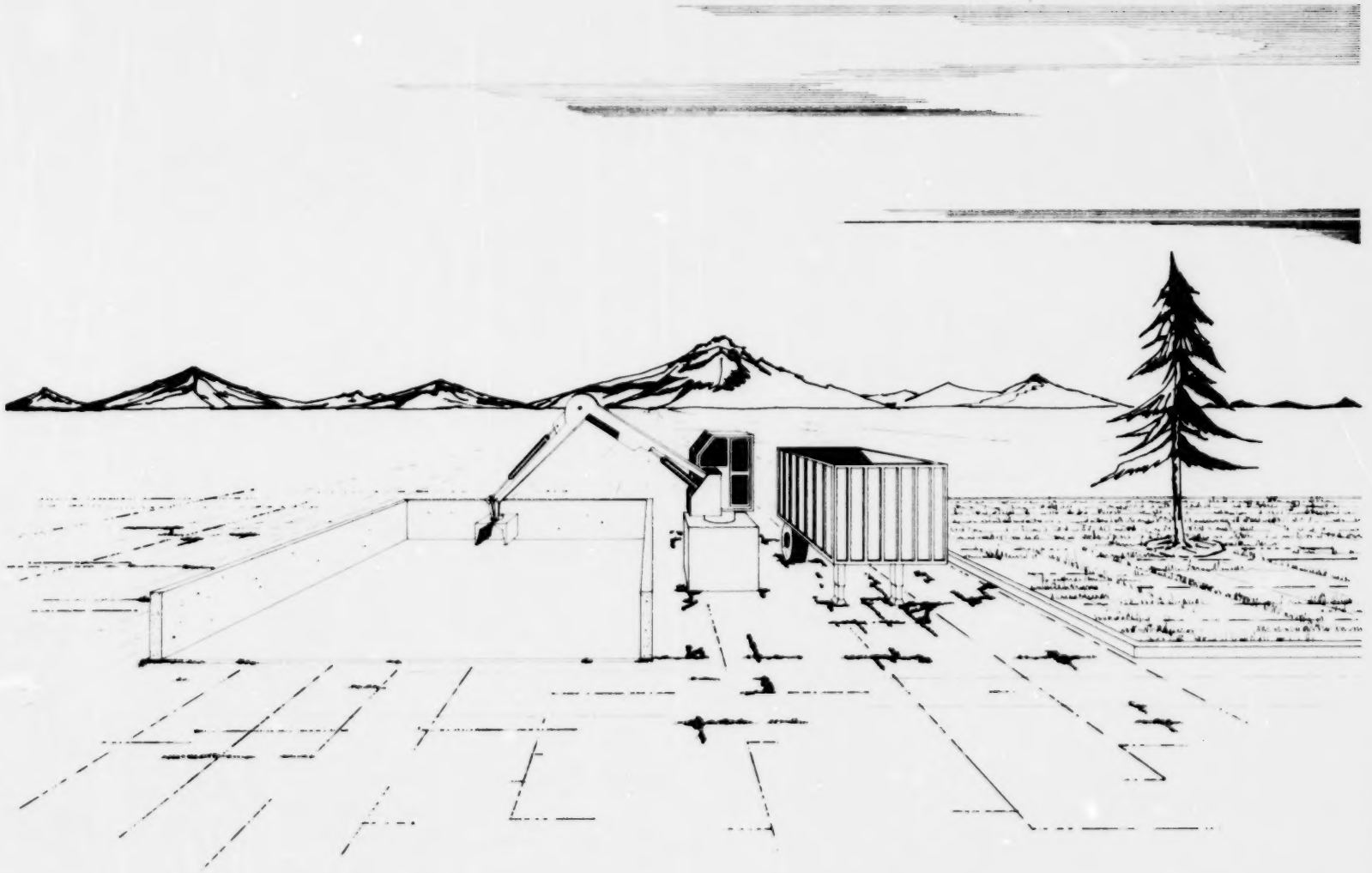


FIGURE 17

TYPICAL LOADING EQUIPMENT FOR
A BUNKER FACILITY

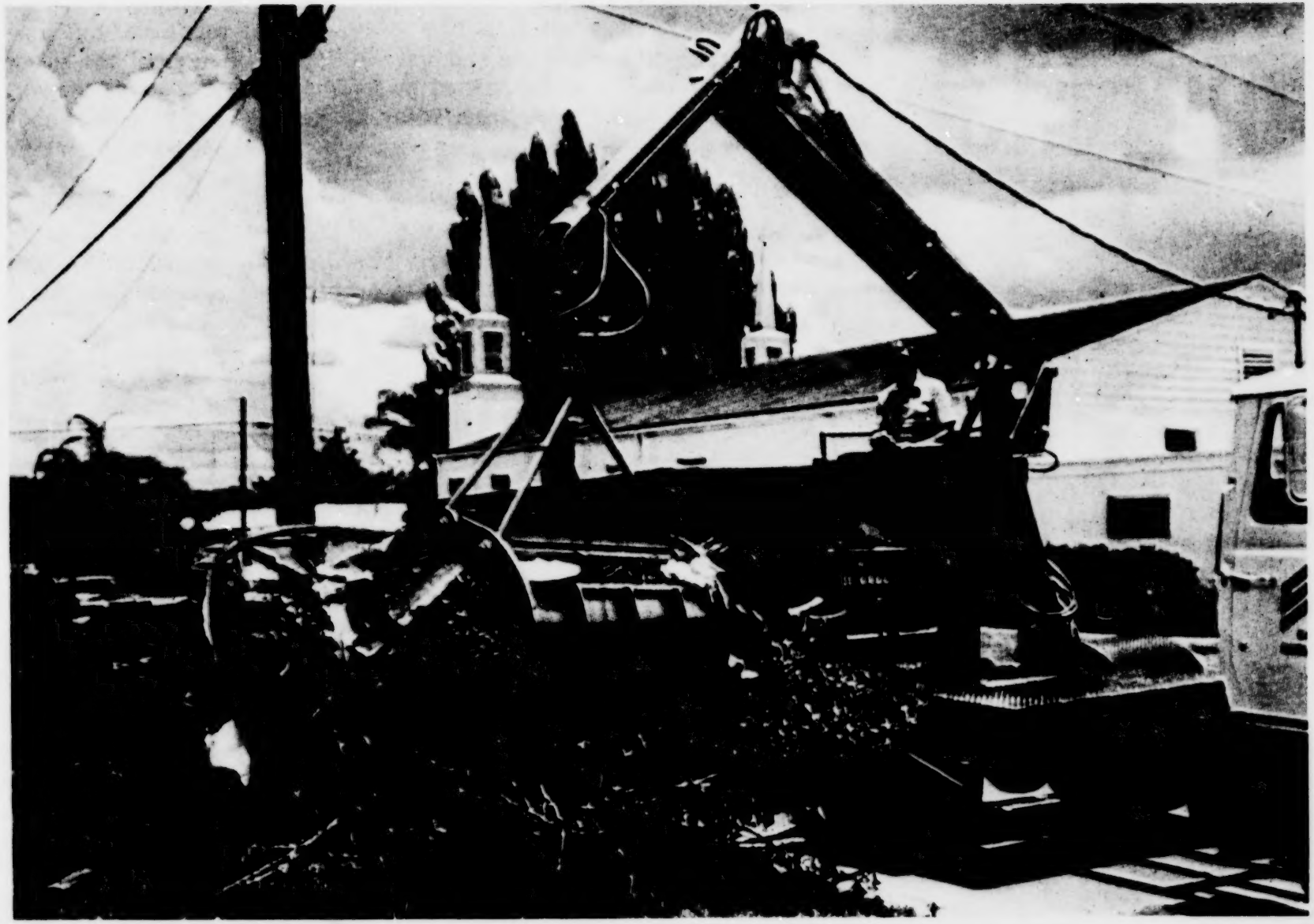


FIGURE 18

TYPICAL TRANSFER TRAILERS

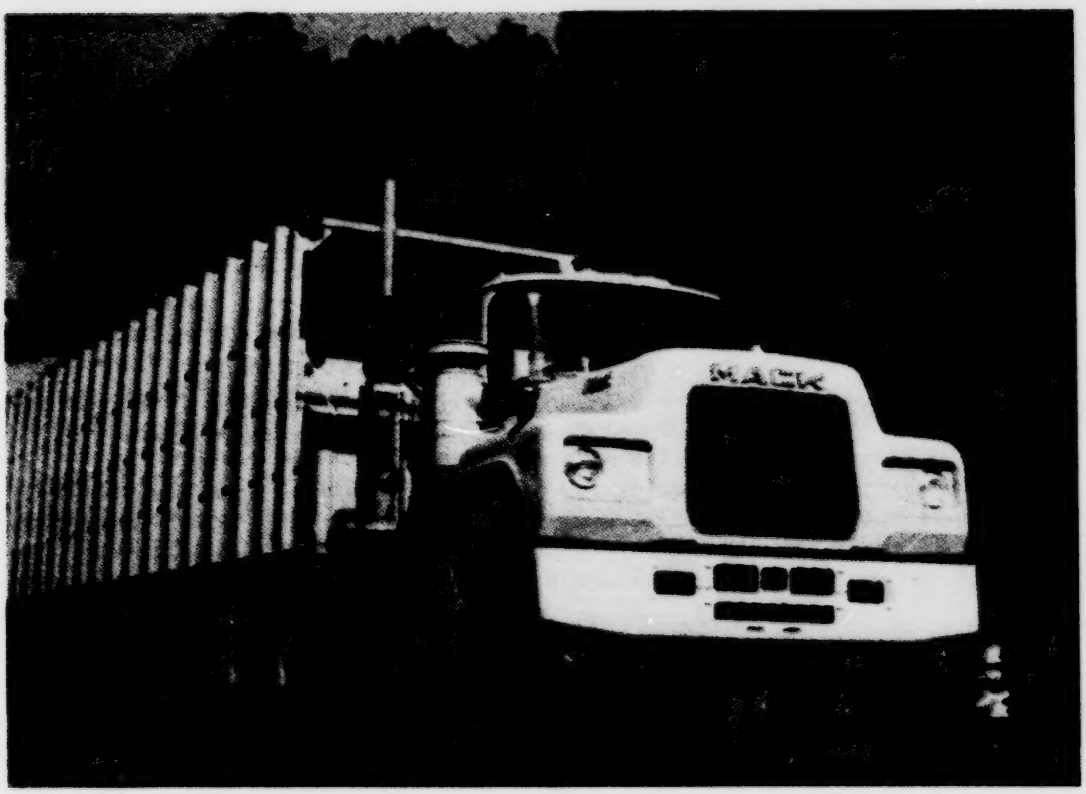


TABLE 3

COMPARISON OF RURAL SYSTEMS AND FACTORS THAT FAVOR THEIR USE

Alternative System	Advantages	Disadvantages	Factors Which Favor Their Use
"Mail Box"	- provides the only true collection service - user fees are easily established - collects from the largest percentage of people - provides the highest level of service - no site development required	- time consuming and very costly in isolated areas - limited to the collection of normal household wastes - waste generator has to remember the collection day	- high population concentrations - mandatory collection regulations - citizen preference
"Green Box"	- low manpower use - high public appeal - reduces indiscriminate waste dumping - flexible to waste production changes - minimum site development	- low level of service - costly for low density areas - limits refuse to container size - high site littering possibility - will not handle truck off loading - difficult to assess user fee - requires site development	- high population density - road network capable of handling G.V.W. of 51,000 lbs. - space available for container sites - total user participation - abandonment of nearby open dump - dry disposal sites established in area
"Drop Box"	- low manpower use - reduces indiscriminate waste dumping - high public appeal - easy to establish - can handle a greater variety of wastes	- sites generally spaced further apart - subject to vandalism - difficult to assess user fee - provides lesser level of service - requires extensive site development	- low population concentrations - existing high rates - lack of existing service - moderate or low waste loads - abandonment of open dumps
"Stationary Facilities"	- low manpower use - provides a complete disposal facility - low operating costs - can eliminate indiscriminate waste dumping - high public appeal - low impact on existing collection services	- high capital costs - requires very extensive site development - user fee difficult to establish - requires additional site control	- closing of rural open dumps - sanitary landfills at great distances from service area - road network capable of handling G.V.W. of 80,000 lbs.

2.3 PLANNING

The initial step in planning solid waste systems in rural areas is to clearly determine the objectives. The objectives to be achieved usually fall into four categories or a combination of the same. These objectives are:

- A policy to abandon small open dumps within a specific region.
- A policy to provide an improved or expanded service to the residents.
- A policy to provide a cleaner environment.
- A policy to conform with existing regulations.

Once the objectives have been determined, it becomes necessary to identify the factors affecting solid waste management planning. These factors also fall into a number of categories:

- To define the existing solid waste management service area, whether it be one municipality or a number of municipalities.
- To identify and determine the capacity, extent of service, quality, costs and other attributes of all existing collection systems within the area.
- To determine the quality of existing refuse storage practices for all solid waste sources.
- To determine environmental impact of existing waste management practices.
- To identify all existing disposal, transfer sites and facilities and determine their remaining life, cost and acceptability.
- To determine local political, economic and social factors affecting solid waste management.
- To describe and assess the existing solid waste management systmes and summarize the existing problem areas.
- To project future solid waste management needs for the study area.
- To determine if improvement to existing solid waste management practices is actually necessary.

In determining these conditions, all available alternatives to existing practices must be evaluated. This examination of the alternatives must consider the economical and technical feasibility, ability to accommodate future needs, and, political acceptability.

From the list of alternatives, the systems most appropriate to the planning area are selected. Public relations programs are implemented to inform prospective system users prior to the system adoption. If the final plan is not publically acceptable, modification should be considered, as lack of citizen co-operation could doom the proposed system to failure.

Finally, the system has to be implemented. This may require the passing of additional local bylaws. The formation of a "Waste Management Authority" under a regional solid waste system may be contemplated. In addition, a financing plan has to be formulated and responsibility must be assigned for operation of the system.

2.4 REGIONALIZATION

As time progresses, governmental regulations affecting the management of solid waste grow more stringent, while the system capital and operating costs increases with the increasing quantity of wastes generated. Small communities and rural areas find it increasingly difficult to effectively or efficiently operate their solid waste management systems. One current approach to meet these problems is the establishment of solid waste management districts, a form of regionalization. The basic philosophy of regional solid waste management is to; achieve as closely as possible the implementation of the least cost solution to a common problem within a given service area. The amalgamation of several communities or rural areas in solid waste management practices normally allows them to financially and politically accomplish together what they cannot attain alone.

It is generally accepted that long-term and successful solutions to solid waste management usually encompass a geographic area which is larger, or at least difficult from many traditional political boundaries. Two of the most significant reasons for an examination of solid waste management on a regional basis are:

- The extent of pollution effects associated with inadequate waste disposal, for example - drifting smoke from burning at open dumps, has little relationship to political boundaries.
- The set of viable options available for solving waste management problems, increase, as the size of the geographic area is enlarged.

Regionalization offers a number of potential advantages to both small and large municipalities. The resultant collection disposal methods reduce overall solid waste management costs in the following manner:

- The collection function constitutes roughly seventy percent of the total cost of solid waste handling systems. By grouping several small collection areas (independent towns and villages), a reduction in overall collection costs is generally achieved.
- Larger service areas make a greater volume of waste available for disposal. As such the per ton landfill costs are reduced thus reducing the individual user cost. Conversely, transport costs remain very stable on a cost per-ton-mile basis, showing little impact by increase or decrease to volume of wastes.
- There are usually environmental, financial, and esthetic advantages to having one large, properly operated sanitary landfill, serving an area, rather than numerous open dumps which are rarely equipped to provide an acceptable level of waste management.

At present, many of the rural collection systems operating throughout North America function under some form of regional structure.

In these systems local communities have grouped together to form non-profit waste management authorities. These authorities can effectively deal with the entire solid waste management program in their larger geographic area. Within the Province of Alberta, several areas now conduct the management of solid waste program under this regional structure. However, the differing local laws and specific needs of the system participants results in considerable variation among existing organizations.

In attempting to analyze the regional concept to solid waste management, it is of primary importance to recognize all local government structures within the proposed system area as they relate to the solid waste management field.

SECTION 3

URBAN TRANSFER STATIONS

3.1 INTRODUCTION

As the urban areas around cities expand fewer nearby locations are left which qualify as acceptable solid waste disposal sites. This has necessitated the transportation of wastes over much greater distances to the final disposal sites. The cost of direct haul by individual collection vehicles increases proportional to the distance from the collection route to the disposal site. Wastes can be transferred from collection vehicles to large capacity trucks, etc., for haul to distant disposal sites. In other cases, it may not be feasible or even possible to haul solid wastes in collection vehicles directly to disposal sites which in turn may necessitate the use of transfer stations.

The overall concept of transfer stations dates back to the period when collection units were drawn by horses. In those times, it was common to use transfer stations, whenever, hauls from the collection route to the disposal point was more than three to four miles. In later years, many transfer operations were abandoned with the introduction of large, fast moving collection trucks. However, as metropolitan areas increased in population and size, haul distances have increased, necessitating the re-introduction of transfer stations to solid waste management systems in urban areas.

A transfer station is a facility where solid waste from several relatively small vehicles is transferred into larger containers or units for the haul to a disposal site. The small vehicles can be private automobiles and trucks, or more commonly, private or municipally owned collection vehicles. The large units may be tractor-trailer combinations, containers, rail cars or barges. Barge haul does not appear to have much potential for development in the near future except in very specialized applications. In a similar manner, rail haul has generated considerable interest in the past several years, but the concept has not been universally accepted.

Although a transfer system offers potential savings in terms of manpower and collection equipment requirements, such a system also incurs specific additional capital and operational costs. A detailed cost benefit analysis is required in every proposal, to ensure that the final overall costs for the solid waste management system are not increased by implementing transfer facilities. Expenditures that are fundamental to a transfer system include:

- Capital costs for land, structures, stationary and mobile equipment.
- Operational costs for labor, utilities, maintenance, and overheads at the transfer stations.
- Operational costs for labor, maintenance, and overhead incurred in the hauling of wastes from the transfer station to the disposal site.

The utilization of a transfer operation within the total solid waste system, can result in specific cost savings in the following way:

- The non-productive time of collection crews is reduced since they no longer travel from the routes to the disposal site. In large operations, it is entirely possible that the number of collection crews can be reduced due to the increased productive collection time.
- The reduction in mileage travelled by the collection vehicle, will produce a savings in operating costs for the collection department.

- Past experiences have proven that many of the mechanical breakdowns to collection vehicles such as; drive trains, suspensions and tires occurs at the landfill site. The maintenance costs on collection vehicles are reduced, when the units no longer direct haul to the landfill site.

- The capital cost of collection equipment can be reduced, since smaller trucks can generally be used and the truck fleet size decreased.

In considering the use of transfer systems in urban areas, the primary variable is the distance to the disposal site. There is no firm rule whereby distance can be measured in miles. Distance to the disposal site is an important factor in comparing the direct haul with transfer haul. However, a more realistic criteria is the time necessary to travel the distance. The major item in total haul costs is labor, which is directly related to time rather than distance. Factors such as existing wage rates, type of access roads, collection truck capacity and collection crew size can dramatically change the economical breakeven distance.

At the present time urban transfer stations operationally are of two distinct types:

(1) direct dump and (2) hydraulic compaction. The main difference between the two are in the final handling of waste materials at the facility. The direct dump system is the simplest concept. In this type of station, waste materials delivered to the transfer facility are either:

- dumped directly from the delivery unit by gravity into the top opening of the transport trailer, container etc., or,

- dumped on the transfer station floor. The wastes are then mechanically pushed by crawler loaders, bobcats, etc., into the transport units.

The compaction approach can be to:

- dump the waste from the delivery unit directly into the stationary compactor when then feeds the wastes into the transport unit, or,

- dump the waste onto the station floor and then push the materials into the stationary compactor which likewise feeds the transport unit, or,

- dump wastes directly or indirectly into the compaction unit which is an integral part of the transport unit.

In comparing methods of supplemental transportation with direct haul in collection vehicles, it must be recognized that the real purpose is to move a definite quantity of refuse a definite distance. Accordingly, in evaluating the different plans, the cost per ton mile of transport, with all overhead and fixed charges included, is the factor on which the economic selection should be based. The lowest cost per ton mile in transport, however, is not the only consideration. The entire operation must be dependable, sanitary and must meet with public approval.

3.2 DIRECT DUMP VERSUS COMPACTION STATIONS

Many differing and variable opinions exist today as to which type of station fits the needs of the community, at the least cost. From expert-to-expert, discussion-to-discussion and text-to-text the correct method bounces back and forth. In the end, it often seems that the manufacturer with the strongest sales force implements their preferred system.

Before attempting to list the advantages of each system it is of prime importance to look at the principle of the different methods. Direct dump transfer stations using loose haul of wastes were developed using the following guidelines:

- when the majority of wastes receive compaction during the collection activity, why spend additional funding on further compaction, because,
- it has been proven, that collected compacted wastes retain some degree of their compacted density after unloading, and,
- if you transport these wastes using the largest, lightest, legal carrying unit, the regulated G.V.W. (gross vehicle weight) will be met, which in the final analysis is the purpose of a transfer system, and,
- by using conventional truck tractor concepts, the cost should be more economical.

In comparison, the entire refuse industry has for many years moved towards high compaction in the collection transport and disposal components of the total system. In turn even the storage component of the industry has been the subject of increased activity to compact.

Compaction of refuse, must be considered as an additional cost, in trying to increase the density of the waste materials. This applies to compaction of the waste load, whether the compaction is done in the storage, collection or transport components of the total system. The reasoning behind compaction or non-compaction of waste at a transfer station has to be related to:

- can the legal G.V.W. of the transport units be reached without the use of compaction.

The use of compaction type transfer stations will reduce the concern; as to whether the majority of wastes arriving at the station received compaction during the collection process. However, compactors are unable to handle every type of waste arriving at an individual transfer facility. Therefore, at times certain bulky materials have to be removed from the compactor main stream, as bridging at the compactor mouth can be a significant problem. In addition, various metals such as: long steel pieces are normally removed prior to compaction to prevent the steel from puncturing the side of the receiving units.

In summary, the use of direct dump or hydraulic compaction transfer stations requires a careful analyses as to the type of waste to be transferred, the collection processes in place before the transfer component, and, the factual costing of both systems. Only then can a sound decision be made as to the implementation of the proper alternative.

TABLE 4

Urban Transfer Station Alternatives

Alternative	Advantages	Disadvantages
DIRECT DUMP • direct from dump delivery units to container, trailer, etc.	- lowest capital costs. - accommodates low cost hauling units. - simplified loading of haul units. - operation of station least affected by mechanical failures. - handles wastes not easily compacted. - transport haul standard in trucking industry.	- little provision for handling peak incoming waste loads. - distribution of haul weight difficult. - low haul weights possible through non-compaction during collection.
• from delivery units - storage - area pushed into haul units.	- nominal capital costs. - accommodates low cost haul units. - loading technique allows pre-crushing of wastes. - large holding capacity at station. - can easily handle peak incoming loads. - mechanical distribution of load.	- requires additional equipment: bobcat or crawler loaders, etc. - additional operating costs of crawler loader.
HYDRAULIC COMPACTION • direct from delivery unit to compactor hopper, trailer, etc.	- lowest capital cost of compaction type stations. - high density of waste load. - handles most types of waste. - closed type transport unit.	- compactor failure virtually closes station. - transport units have to back into station. - some bulky wastes etc. have to bypass compactor.
• from delivery units - storage area - pushed into compactor, hopper, or conveyor.	- increased storage area for incoming wastes. - station can operate for increased time when compactors fail. - handles most types of waste. - past performance widely accepted. - closed type transport unit.	- requires additional equipment: bobcat, or crawler loader, etc. - additional operating costs of crawler loader. - transport units have to back into station. - usually found in station design over 450-500 tons/day.

3.3 TRUCK TRANSPORT

The popularity of truck transfer systems has led to the development of equipment specifically suited to this purpose. Early transfer station operations relied completely on equipment built by various manufacturers to specifications of the operating authority. In the 1960's, solid waste equipment manufacturers developed specialized processing and hauling equipment. At the present time, those interested in a truck transfer operation have two options. The first option is to design their own system, and write specifications for desired equipment. The second option is to buy specialized equipment from the manufacturers, and design the system around it.

Two basic concepts for transporting wastes with truck units have developed as a result of these options, namely:

- Loose haul: which generally means that the wastes receive no compaction during the transfer operations. However, the materials may have been compacted during the collection activity. The station is previously described as a direct dump system.
- Compacted Haul: In this system the transferred wastes are compacted during the actual transfer operations through various techniques. Described earlier as a compaction type station.

All loose-haul systems are characterized by the use of open-top trailers and equipment not specially predesigned for solid waste transfer. Transfer trailers with live bottom floors, which enable the movement of materials from the trailer at the disposal site, and/or units with a pull blade are most commonly used in this system. At the present time, the City of Edmonton uses live bottom trailers for transport in their transfer operations. These trailers are also in use hauling waste from Banff National Park to the City of Calgary landfills. In the rural system of the Drumheller area, live bottom trailers are presently in operation.

The second basic transport system utilizes hydraulic pressure to achieve horizontal compaction of the waste within the trailer. Two methods have been used to achieve compaction. Both are characterized by the use of enclosed reinforced-steel trailers specifically manufactured for solid waste transfer. The first compaction method is partially a direct-dump operation in that waste is dumped directly into the trailer, near the front. A hydraulic-powered bulkhead tranverses the length of the trailer and compacts the waste against the rear doors. The entire compaction process is self-contained within the trailer body. At the disposal site, the rear doors are unlatched and the travelling bulkhead pushes the load out through the rear opening.

The second compaction method requires the use of a stationary compactor. The transfer vehicle is backed up and securely fastened to the compactor. Waste is fed by gravity into a compaction chamber from an overhead hopper. The compaction ram then forces the waste forward into the trailer through the rear in horizontal reciprocating cycles. The trailer is also equipped with a hydraulic-powered bulkhead which pushes the compacted refuse from the trailer at the disposal site.

The maximum legal payload for any transport unit is governed by Provincial regulations for gross weight, axle weight, as well as limitations on length, width, and height of the trailers and/or tractor. To determine the optimum configuration, the designer must work backwards from these limitations. Direct-dump systems with limited compaction require large-volume trailers to reach maximum payloads. Compaction systems need smaller volumes because of the higher densities, but structural reinforcement of these trailers increases the tare weight and usually lowers the payloads.

FIGURE 19
ARCHITECTURAL CONCEPT OF A DIRECT DUMP STATION

Incoming wastes are dumped onto a concrete slab. The crawler loader pushes these wastes into the top of a loose haul trailer. Station can be built with building enclosure.

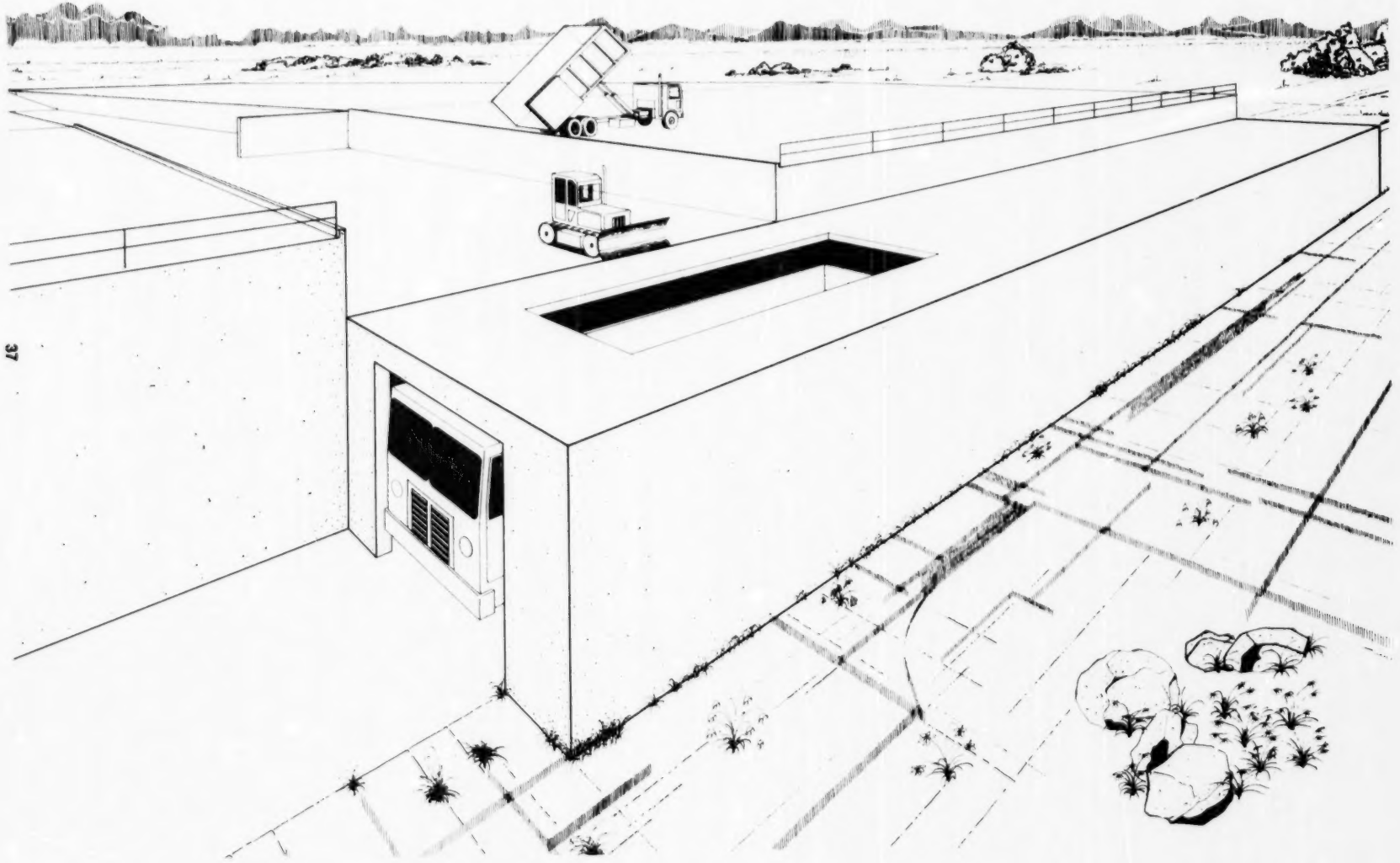


FIGURE 20
ARCHITECTURAL CONCEPT OF A STANDARD TRANSFER BUILDING
(Front View)

Incoming waste loads enter building through one of the four doors. Wastes are dumped on the building floor, and then pushed into the top of the transport unit or compactor.

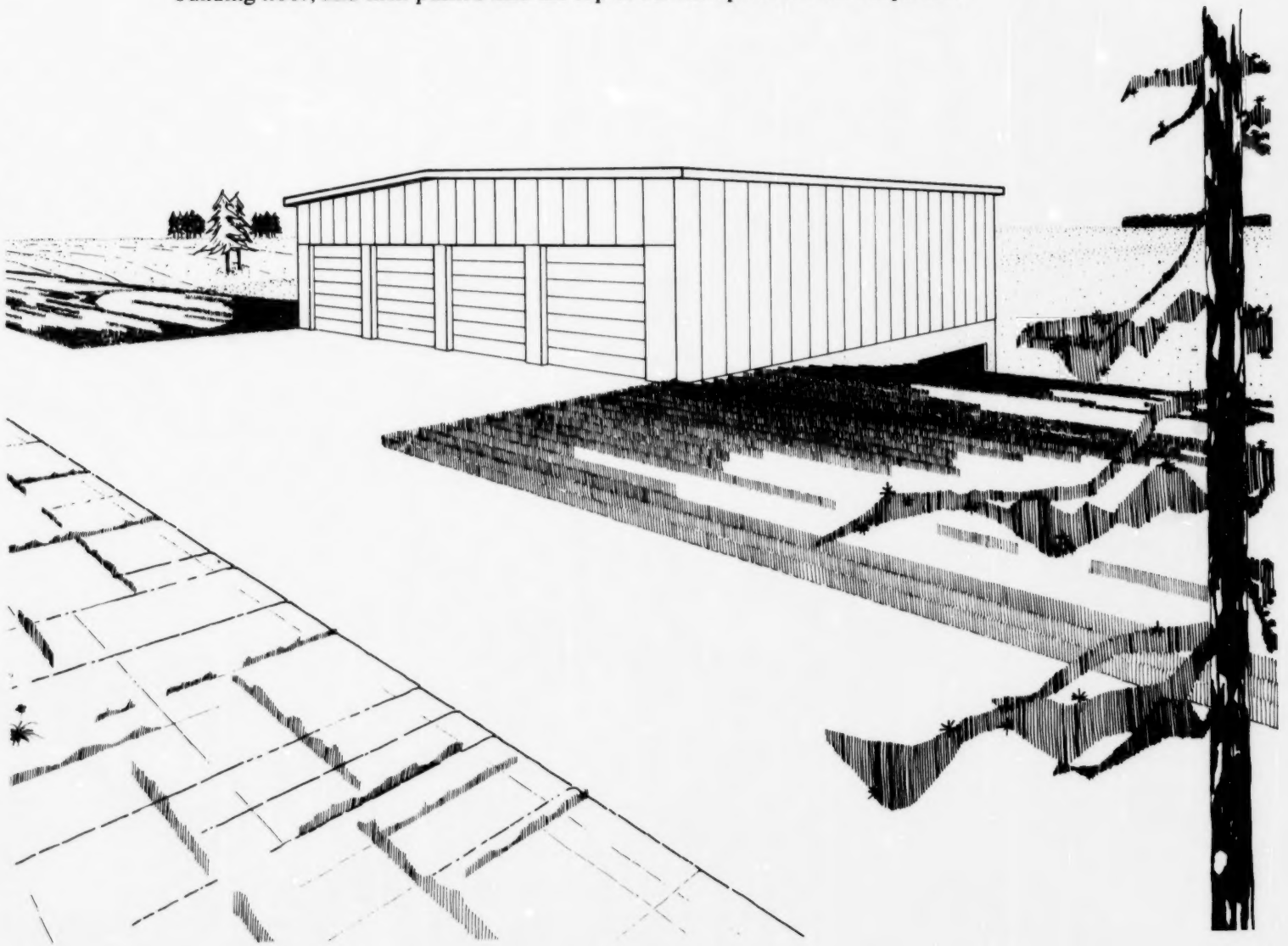


FIGURE 21
ARCHITECTURAL CONCEPT OF A STANDARD TRANSFER BUILDING
(Rear View)

Transfer trailer passes through building from left to right. This concept suitable for compaction or direct dump stations.

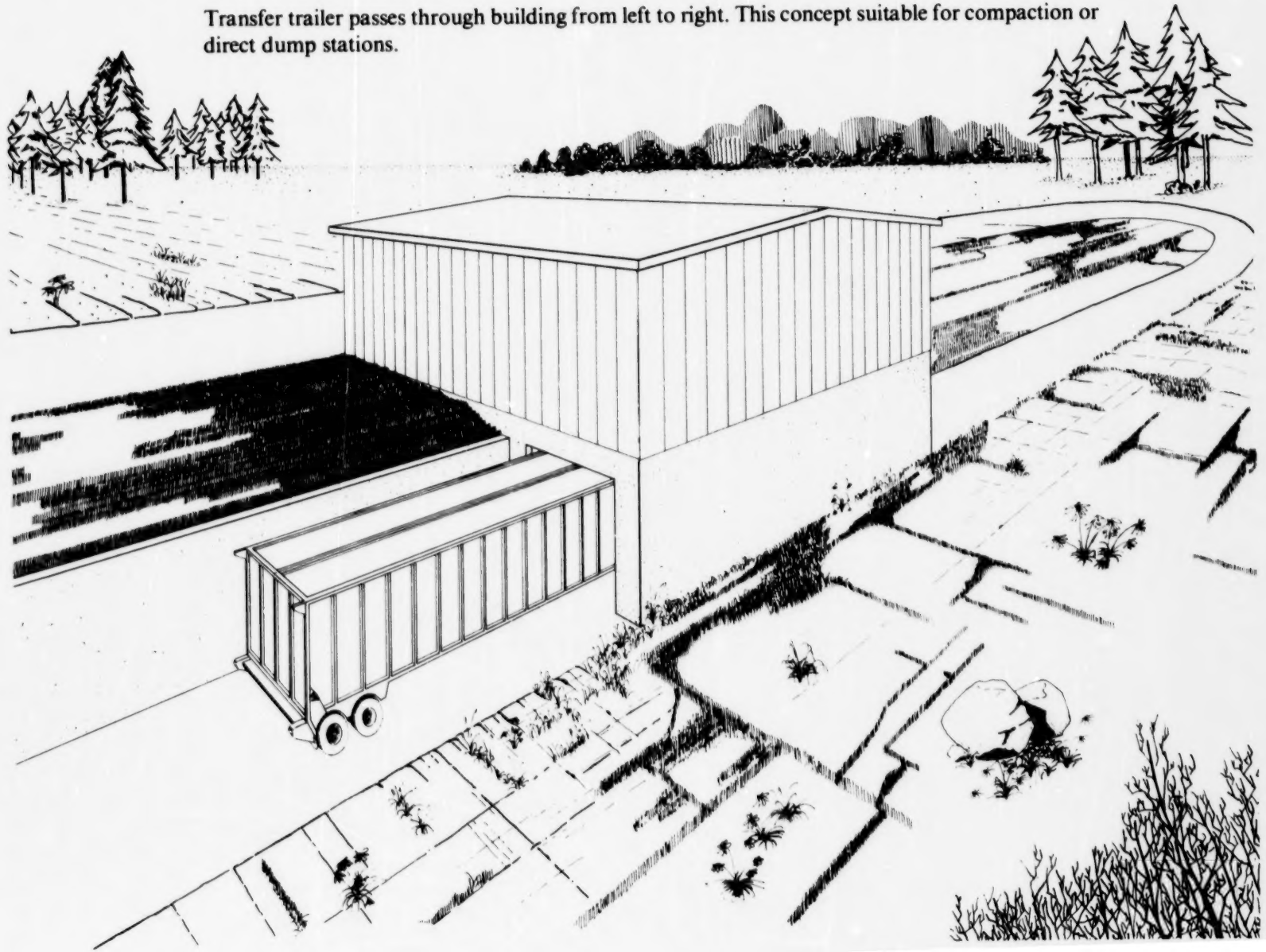


FIGURE 22

ARCHITECTURAL CONCEPT OF A SINGLE COMPACTOR STATION

Depicted is a station using a single compactor which compacts waste into a 75 cu. yd. transfer trailer. Incoming wastes are dumped directly into the compactor hopper.

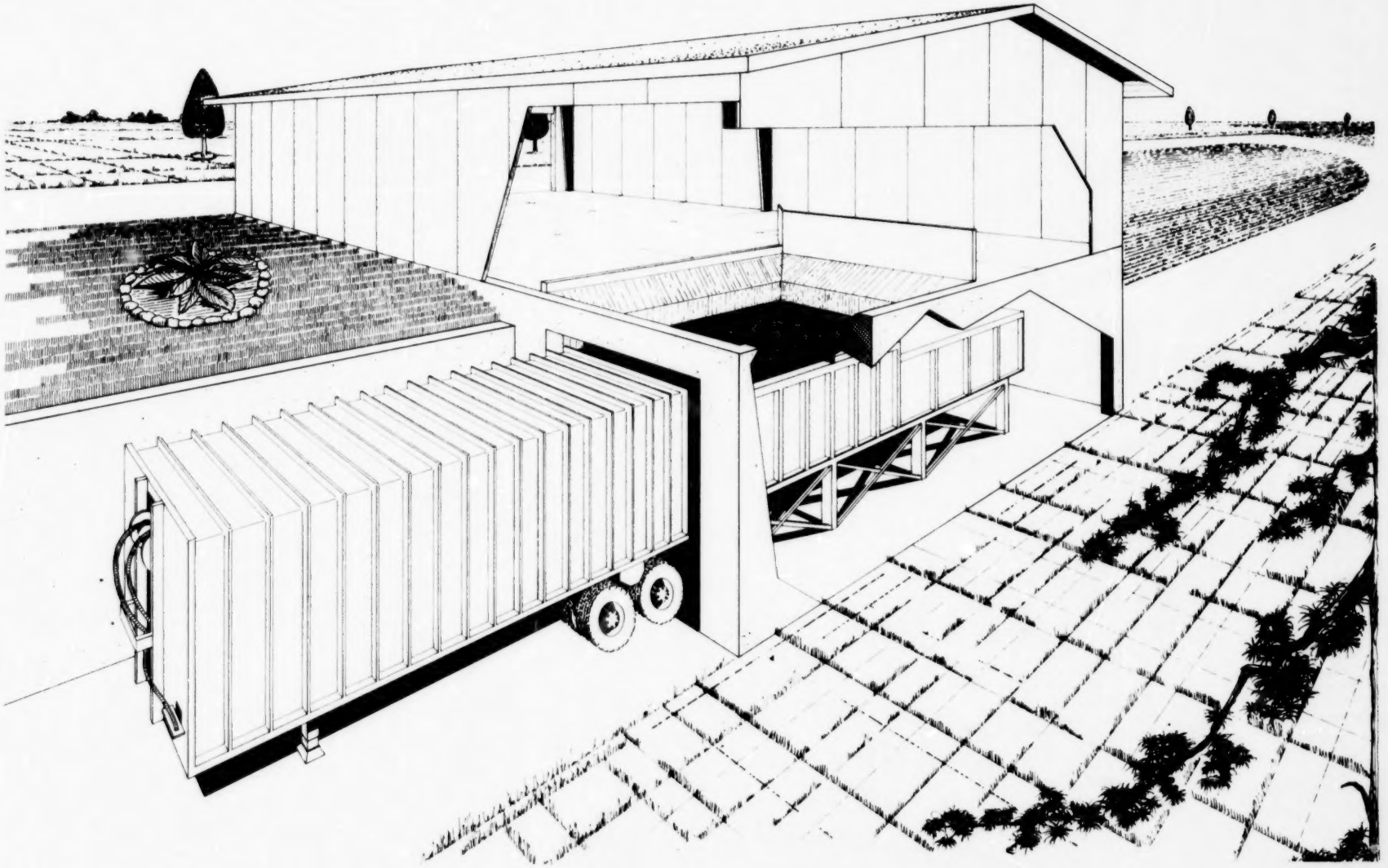


FIGURE 23

ARCHITECTURAL CONCEPT OF A DOUBLE COMPACTION TYPE STATION

Depicted is a station using two compactors. The incoming wastes are dumped onto the reversible conveyor which carries the materials into one of the compactor units. Compactor on the right is feeding a roll-off container, left compactor feeds a transfer trailer.

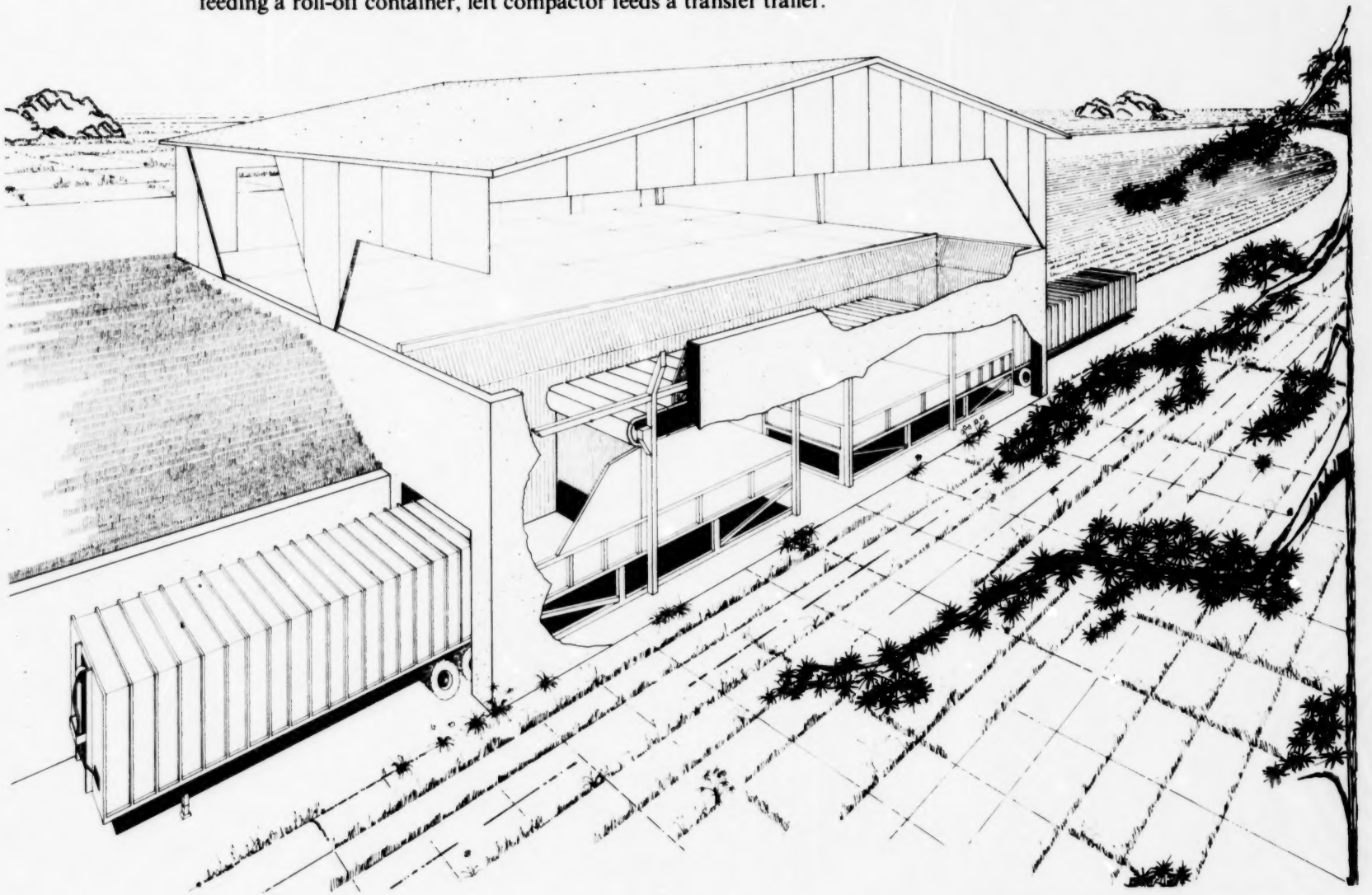


FIGURE 24
ARCHITECTURAL CONCEPT OF A
RURAL DIRECT DUMP SITE

*The major disadvantage of this system design is that the transfer trailer has to be left on site as the receiving container.

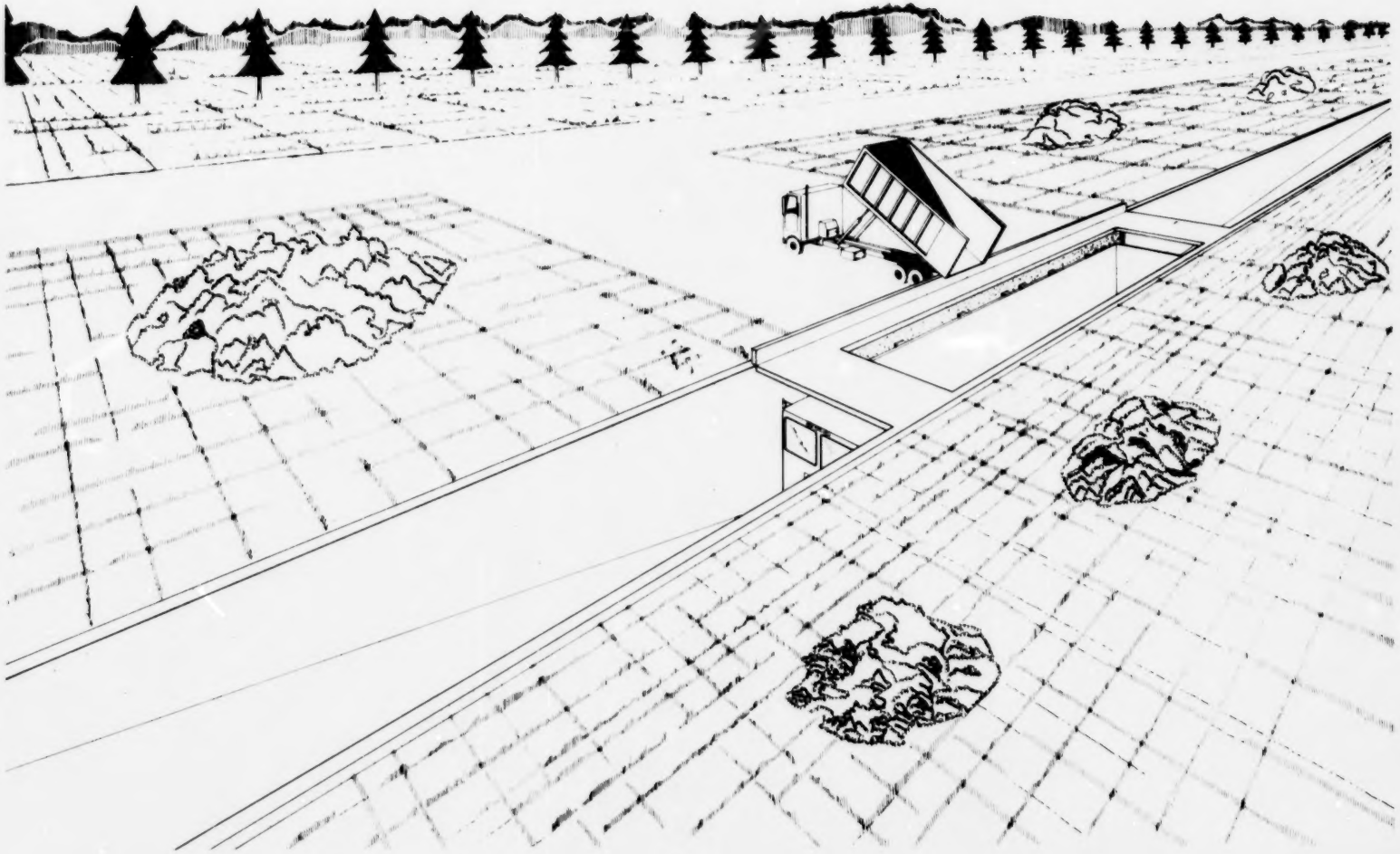
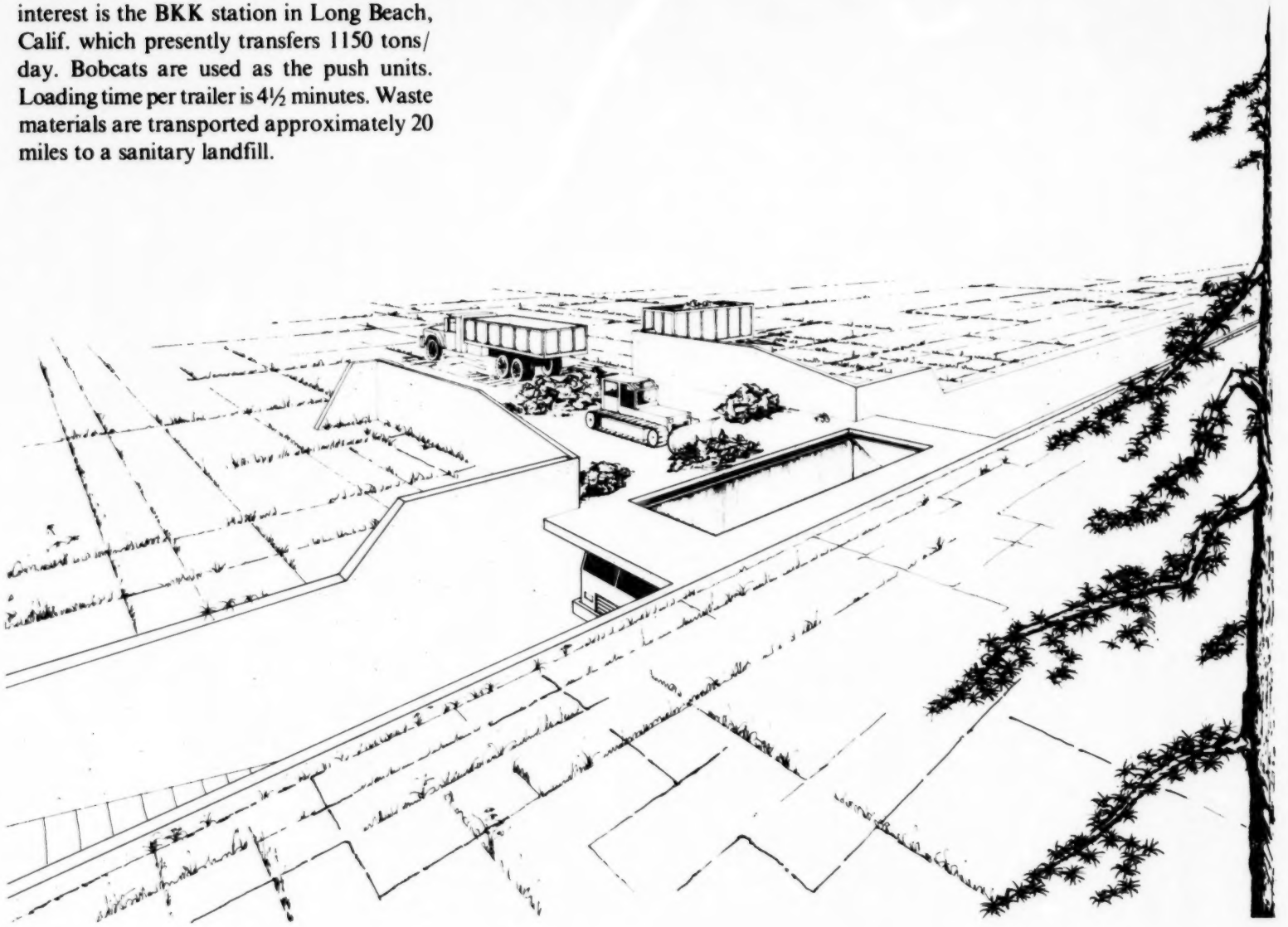


FIGURE 25
ARCHITECTURAL CONCEPT OF A
PUSH PIT DIRECT DUMP STATION

*Several stations of this type are in operation in the Western United States of particular interest is the BKK station in Long Beach, Calif. which presently transfers 1150 tons/day. Bobcats are used as the push units. Loading time per trailer is 4½ minutes. Waste materials are transported approximately 20 miles to a sanitary landfill.



SECTION 4

TRANSFER STATION vs DIRECT HAUL

4.1 INTRODUCTION

Throughout the preceding pages we have mentioned that transfer stations offer a convenient, efficient and environmentally acceptable alternative to the direct hauling of refuse to distant disposal sites. By consolidating the refuse into larger specially designed transport units, significant savings can be realized. In any urban transfer operation, the costs of owning and operating the station itself are entirely unproductive and must be "earned back" by the greater efficiency of the haul vehicle being used. Other unproductive expense may also be incurred at the disposal site, inasmuch as the transfer vehicle may have a longer unloading time than a collection vehicle. A break even analysis technique provides a simple method to determine if a transfer facility is warranted in a given situation. This methodology is best illustrated through a series of examples. However, all examples are simply an illustration of the technique; the cost figures cited cannot be generalized, as transfer facility costs are highly site specific.

In addition, the interrelationship of the other components of the total solid waste management system play an important role in determining the justification of using transfer operations and in fact the distance one can economically transport waste materials. As such, even the size of the entire service area may be dictated by these costs.

The first step in the analysis of transfer vs direct haul is to put all costs on a per ton basis. For haul costs, whether it relates to direct haul or transfer haul we reflect the units of dollars per ton-mile. In certain circumstances, dollars per ton-minute units are more accurate as they reflect differing driving conditions caused by traffic, varying road types, etc. Handling costs at transfer stations are also presented on a per ton basis.

The accurate loadings and costs of operating various refuse collection equipment types is of prime importance in determining transfer station economics. Both these factors are unobtainable if past practices have not included scaling of collection loads or factual accounting documentation. Costs relating to collection equipment have been obtained from various private haulers throughout the Province.

These costs are presented on the following pages and cover the most commonly used collection vehicles within the Province.

TABLE 5

RATED CAPACITY AND ESTIMATED LOADINGS FOR COMMON REFUSE UNITS

TYPE OF UNIT	NOMINAL CAPACITY CUBIC YDS.	AVERAGED NOMINAL LOADING IN TONS
OPEN DUMP TRUCK*	18	1.3
HAUL-ALL #12	12	1.7
HAUL-ALL CURBSTER	12	2.1
REAR END LOADER	16	4.4
REAR END LOADER	20	5.9
REAR END LOADER	25	7.8
SHUPAK SIDE LOADER	25	5.7
FRONT END LOADER	30	8.0
FRONT END LOADER	33	8.5
ROLL-OFF UNIT*	40	3.5
ROLL-OFF UNIT*	50	4.4
LUGGAR UNIT*	12	.8
LUGGAR UNIT*	20	1.4
LIVE BOTTOM TRAILER (1)	112	20.1
LIVE BOTTOM TRAILER (2)	112	11.3
COMPACTION TRAILER	65	16.5

NOTE:

- Nominal capacity expressed in cubic yards is the manufacturer's rating. Nominal weight expressed as loading in tons was taken from actual scale tickets of units carrying normal refuse. These were then averaged, therefore, at various times of the year the indicated loadings are subject to significant increases and/or decreases.
- (1) Trailers operating Banff to Calgary - majority of waste load received compaction during the collection process.
- (2) Trailers operating in the Drumheller rural system - majority of waste load received no compaction during the collection process. In addition it has been determined that 80% of the total waste load is material other than normal household waste.

* operating in rural systems

TABLE 6

CAPITAL RECOVERY FACTORS
(USED IN RETIRING CAPITAL DEBT LOAD)

Years	Interest Rates 6%	8%	10%	12%	15%	20%
1	1.06000	1.08000	1.10000	1.12000	1.15000	1.20000
2	0.54544	0.56077	0.57619	0.59170	0.61512	0.65455
3	0.37411	0.38803	0.40211	0.41635	0.43798	0.47473
4	0.28859	0.30192	0.31547	0.32923	0.35027	0.38629
5	0.23740	0.25046	0.26380	0.27741	0.29832	0.33438
6	0.20336	0.21632	0.22961	0.24323	0.26424	0.30071
7	0.17914	0.19207	0.20541	0.21912	0.24036	0.27742
8	0.16104	0.17401	0.18744	0.20130	0.22285	0.26061
9	0.14702	0.16008	0.17364	0.18768	0.19957	0.24808
10	0.13587	0.14903	0.16275	0.17698	0.19925	0.23852
11	0.12679	0.14008	0.15396	0.16842	0.19107	0.23110
12	0.11928	0.13270	0.14676	0.16144	0.18448	0.22526
13	0.11296	0.12652	0.14078	0.15568	0.17911	0.22062
14	0.10758	0.12130	0.13575	0.15087	0.17469	0.21689
15	0.10296	0.11683	0.13147	0.14682	0.17102	0.21388
16	0.09895	0.11298	0.12782	0.14339	0.16795	0.21144
17	0.09544	0.10963	0.12466	0.14046	0.16537	0.20944
18	0.09236	0.10670	0.12119	0.13794	0.16319	0.20781
19	0.08962	0.10413	0.11955	0.13576	0.16340	0.20646
20	0.08718	0.10185	0.11746	0.13388	0.15976	0.20536
21	0.08500	0.09983	0.11562	0.13224	0.15842	0.20444
22	0.08305	0.09803	0.11401	0.13081	0.15727	0.20369
23	0.08128	0.09642	0.11257	0.12956	0.15628	0.20307
24	0.07968	0.09498	0.11300	0.12846	0.15543	0.20212
25	0.07823	0.09368	0.11017	0.12750	0.15470	0.20212
26	0.07690	0.09251	0.10916	0.12665	0.15407	0.20176
27	0.07570	0.09145	0.10826	0.12590	0.15353	0.20147
28	0.07459	0.09049	0.10745	0.12524	0.15306	0.20122
29	0.07358	0.08962	0.10673	0.12466	0.15265	0.21012
30	0.07265	0.08883	0.10608	0.12414	0.15230	0.20085

TABLE 7

ESTIMATED COSTS TO OWN AND OPERATE MOBILE EQUIPMENT

	Approx. Capital Cost (1982)	FIXED COST $ PER YR.	FIXED COST $ PER HR.	VARIABLE COST PER HR.	TOTAL COST OWN and OPERATE HR.
OPEN DUMP TRUCK	$ 17,200	$ 4,180	$ 2.10	$19.90	$ 22
HAUL ALL #12	$ 20,400	$ 4,960	$ 2.50	$25.50	$ 28
HAUL ALL CURBSTER	$ 21,000	$ 5,100	$ 2.55	$26.45	$ 29
REAR END LOADER 16 cu. yds	$ 59,000	$14,350	$ 7.20	$29.80	$ 37
REAR END LOADER 20 cu. yds	$ 64,500	$15,690	$ 7.85	$32.15	$ 40
REAR END LOADER 25 cu. yds	$ 76,300	$18,560	$ 9.30	$32.70	$ 42
SHUPAK SIDE LOADER	$ 81,000	$19,700	$ 9.85	$34.15	$ 44
FRONT END LOADER	$ 82,500	$20,070	$10.00	$39.00	$ 49
FRONT END LOADER	$ 84,000	$20,430	$10.20	$39.80	$ 50
ROLL-OFF	$ 77,000	$18,730	$ 9.35	$38.65	$ 48
LUGGAR UNIT	$ 72,000	$17,500	$ 8.75	$37.25	$ 46
TRUCK & LIVE BOTTOM TRAILER	$114,000	$27,730	$13.85	$38.15	$ 52
TRUCK & COMPACTION TRAILER	$116,000	$28,220	$14.10	$38.90	$ 53

NOTE:

Variable costs include one operator at $10.00 per hour
Fixed Cost per year is interest and retirement of principle at twelve percent over six years
Fixed Cost per hour is based on 2,000 hours operating per year.
All costs in 1982 dollars.

TABLE 8

ESTIMATED OPERATING COSTS OF REFUSE UNITS

TYPE OF UNIT	CREW SIZE	NOMINAL LOADING (TONS)	NOMINAL HIGHWAY TRAVEL SPEED M.P.H.	COSTS (1982 $) PER HR.	PER MILE	PER TON-MILE
OPEN DUMP TRUCK	1	1.3	55	22	.40	.31
OPEN DUMP TRUCK	2	1.3		31	.56	.43
HAUL-ALL #12	1	1.7		28	.51	.30
HAUL-ALL #12	2	1.7		37	.67	.39
HAUL-ALL CURBSTER	1	2.1		29	.53	.25
HAUL-ALL CURBSTER	2	2.1		38	.69	.33
REAR END LOADER (16)	1	4.4	50	37	.74	.17
REAR END LOADER (16)	2	4.4		46	.92	.21
REAR END LOADER (16)	3	4.4		55	1.10	.25
REAR END LOADER (20)	1	5.9		40	.80	.14
REAR END LOADER (20)	2	5.9		49	.98	.17
REAR END LOADER (20)	3	5.9		58	1.16	.20
REAR END LOADER (25)	1	7.8		42	.84	.11
REAR END LOADER (25)	2	7.8		51	1.02	.13
REAR END LOADER (25)	3	7.8		60	1.20	.15
SHUPAK SIDE LOADER	1	5.7		44	.88	.15
SHUPAK SIDE LOADER	2	5.7		53	1.06	.19
FRONT END LOADER (30)	1	8.0		49	.98	.12
FRONT END LOADER (33)	1	8.5		50	1.00	.12
ROLL-OFF UNIT (40)	1	3.5		48	.96	.27
ROLL-OFF UNIT (50)	1	4.4		48	.96	.22
LUGGAR UNIT (12)	1	.8		46	.92	1.15
LUGGAR UNIT (20)	1	1.4		46	.92	.66
LIVE BOTTOM TRAILER (1)	1	20.1		52	1.04	.05
LIVE BOTTOM TRAILER (2)	1	11.3		52	1.04	.09
COMPACTION TRAILER	1	16.5		53	1.06	.06

Note: costs increased at constant $9.00/hr for each additional crew member.

TABLE 9
COMPARISON OF HAUL COSTS

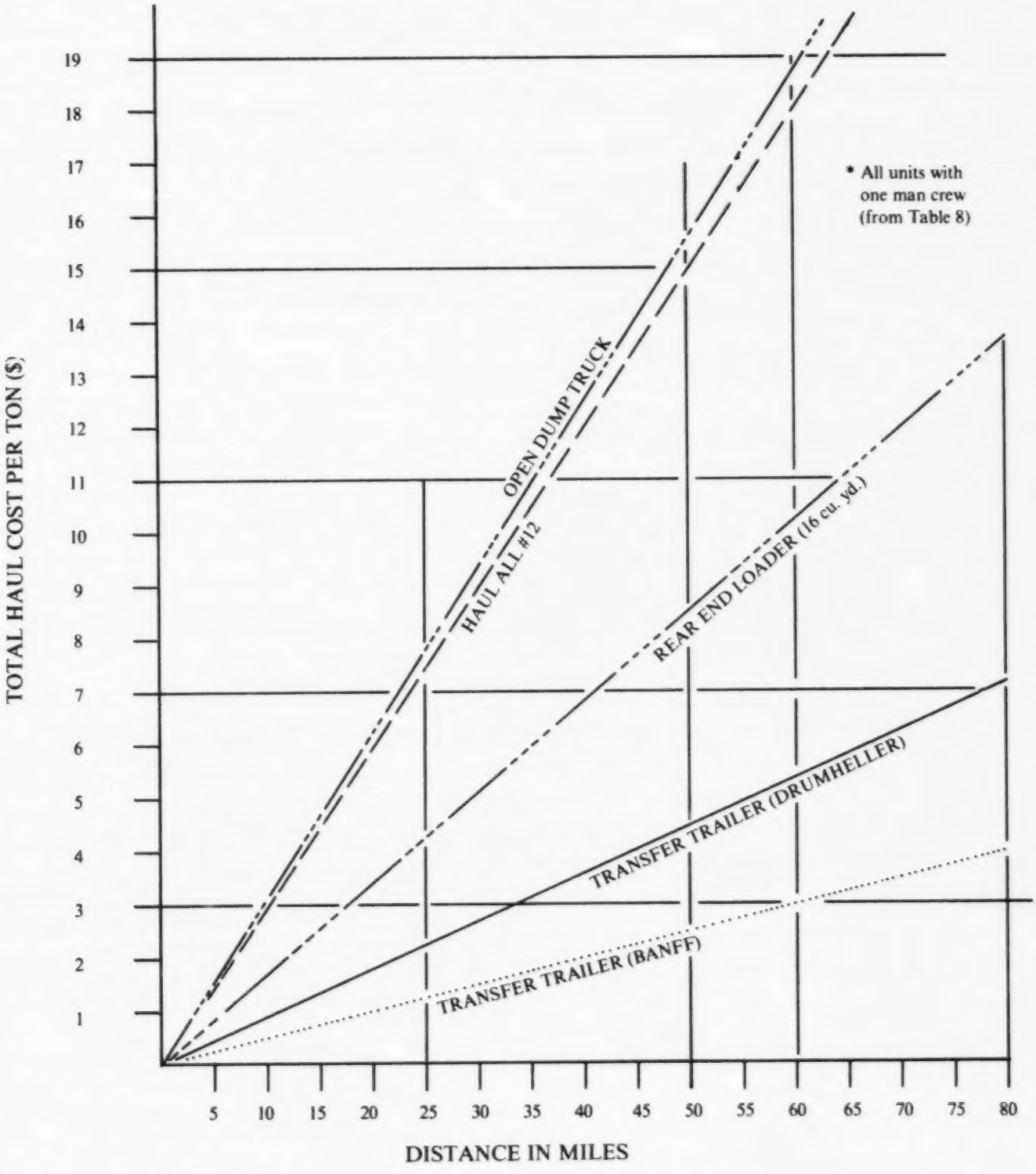
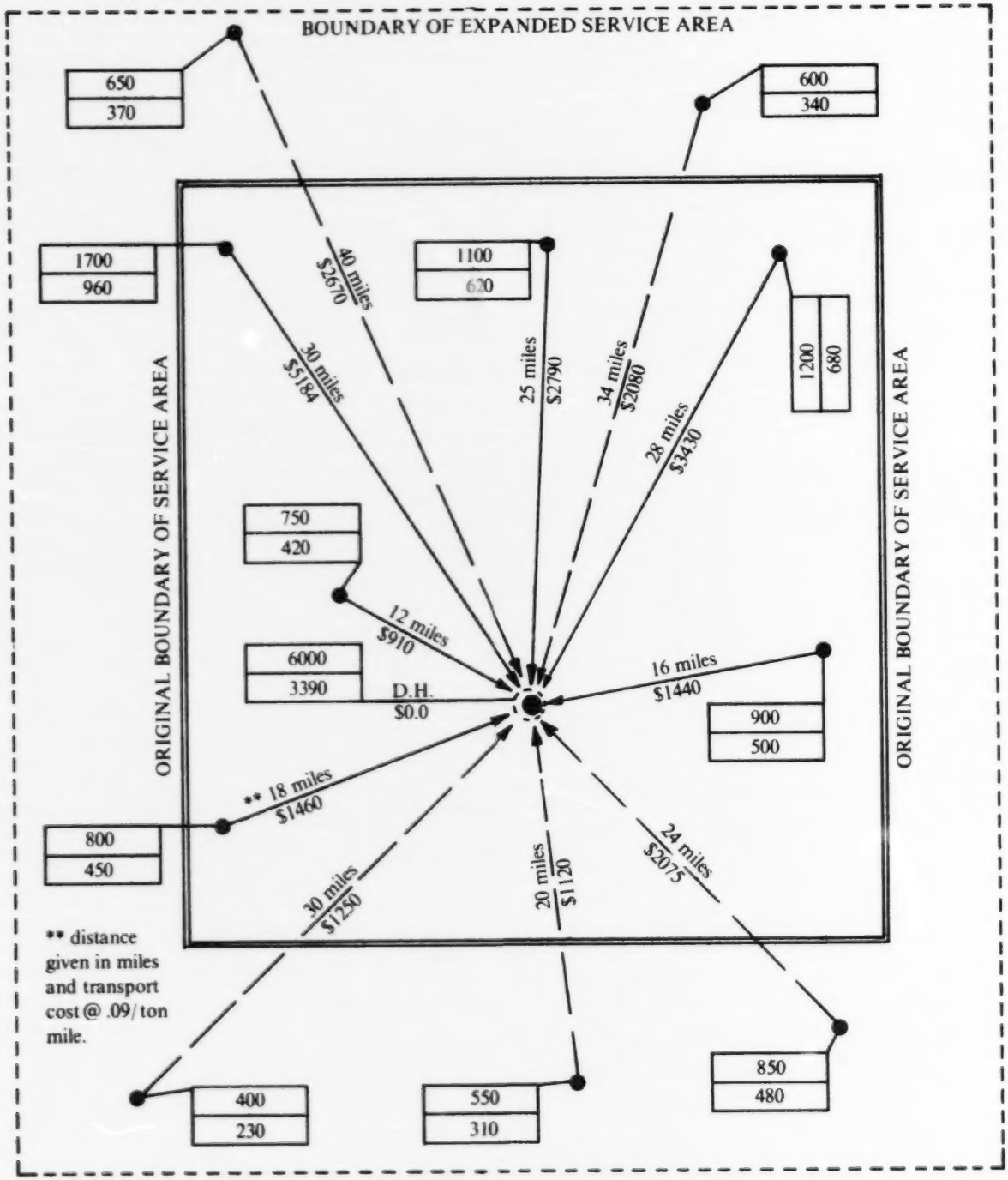


TABLE 10
EXAMPLE OF INCREASING SERVICE AREA SIZE TO REDUCE DISPOSAL COSTS PER TON



Population
Tons/Yr

Note: The original service area population totalled 12,450 residents living in population centres. Based on 3.1 lbs per day refuse generation a total of 7.020 tons/year is available for disposal at the regional landfill for a cost per ton of $17.80. Transport costs are $15,214. By expanding the service area transport costs increase to $24,409 while the disposal costs remain at $125,000 or $14.80 per ton.

SECTION 5

GLOSSARY OF TERMS

5.1 DEFINITIONS

One of the first and most perplexing problems confronting a newcomer to the field of solid waste management is the vocabulary of the industry. To most people in North America there are "garbage men" who collect "garbage" from "garbage cans" and haul it to "garbage dumps" in "garbage trucks". The general public often refers to a sanitary landfill as a garbage dump or to a rubbish collection as a garbage collection. If a person uses a dictionary, he finds "garbage" means "trash", which is "refuse", which means "rubbish", which again means "trash" or "debris".

It is common for many population centres to use one of the many synonyms such as "garbage", "rubbish", or "refuse" to mean all the materials it collects and disposes of. Adding to the confusion in terminology is the wide variation in the refuse collection practices of different areas. For example, some cities collect table scraps, waste paper, tin cans, bottles, and other miscellaneous household wastes and call them "garbage" while other cities use the term "rubbish" to mean the same material.

In the interest of clarity and to confirm an understanding of the terminology concerning solid waste systems, it is considered necessary to define some of the terms used within the industry. The following definitions apply throughout this publication and represent the most widespread meanings of the terms. The technical expressions relating to wastes and solid wastes is generally that used by the American Public Works Association in their various publications.

- SOLID WASTES:-
  Solid wastes or solid waste refers to the useless, unwanted, or discarded materials resulting from society's normal activities. Wastes may be solids, liquids, or gases. Only solid wastes are classed as refuse. The gases are principally industrial fumes and smoke; the liquids consist mainly of sewage and the liquid portion of industrial wastes.
- REFUSE:-
  Refers to solid and semi-solid waste. Its' origin as domestic, institutional, commercial, industrial or accoridng to their nature as organic, inorganic, combustible, non-combustible, putresible, or non-putresible. For purposes of this publication the classification of refuse as shown in Table #11 has been used.
- BULKY WASTES:-
  Bulky wastes are large refuse items such as appliances, furniture, auto parts, trees and branches, stumps, etc.
- INDUSTRIAL REFUSE:-
  Industrial refuse consists of solid waste materials from processing plants and manufacturing enterprises. It is usually of a special character, peculiar to a specific industry. Industrial refuse should not be confused with commercial refuse or so called trade wastes from stores, hotels, restaurants, markets, and similar retail concerns.
- SPECIAL WASTES:-
  Special wastes are hazardous by reasons of their pathological, explosive, radioactive, caustic, or toxic nature. While most of these wastes will be responsibly disposed of by the institution or industry generating them, these wastes from residential or commercial areas occasionally and unexpectedly are put out for normal collection. They are usually solid wastes or liquids in containers, and may be explosive or highly flammable.

TABLE 11

CLASSIFICATION OF REFUSE MATERIALS

Refuse (Solid Wastes)	Garbage	Wastes from the preparation, cooking, and serving of food Market refuse, waste from the handling, storage, and sale of produce and meats		
	Rubbish	Combustible (primarily organic)	Paper, cardboard, cartons Wood boxes, excelsior Plastics Rags, cloth, bedding Leather, rubber Grass, leaves, yard trimmings	From: households, institutions, and commercial concerns such as: hotels stores, restaurants, markets, etc.
		Noncombustible (primarily inorganic)	Metals, tin cans, metal foils Dirt Stones, bricks, ceramics crockery Glass, bottles Other mineral refuse	
	Ashes	Residue from fires used for cooking and for heating buildings, cinders		
	Bulky Wastes	Large auto parts, tires Stoves, refrigerators, other large appliances Furniture, large crates Trees, branches, palm fronds, stumps,		
	Street refuse	Street sweepings, dirt Leaves Catch basin dirt Contents of litter receptacles		From: streets, sidewalks, alleys, vacant lots, etc.
	Dead animals	Small animals: cats, dogs, poultry, etc. Large animals: horses, cows, etc.		
	Abandoned vehicles	Automobiles, trucks		
	Construction & Demolition wastes	Lumber, roofing, and sheathing scraps Rubble, broken concrete, plaster, etc. Conduit, pipe, wire, insulation, etc.		
	Industrial refuse	Solid wastes resulting from industrial processes and manufacturing operations, such as: food-processing wastes, boiler house cinders, wood, plastic, and metal scraps and shavings, etc.		From: factories, power plants, etc.
	Special wastes	Hazardous wastes: pathological wastes, explosives, radioactive materials Security wastes: confidential documents, negotiable papers, etc.		Households, hospitals, institutions, stores, industry, etc.
	Animal and Agricultural wastes	Manures, crop residues		Farms, feed lots

TABLE 12

REFUSE GENERATION GUIDELINE

CLASSIFICATION	SOURCE	QUANTITIES OF WASTES GENERATED PER DAY
* RESIDENTIAL	PRIVATE HOMES	6.5 lbs. basic plus 1 lb/bedroom
	APARTMENTS	3 lbs./bedroom
COMMERCIAL	OFFICE BUILDINGS	1 lb./100 sq. ft.
	DEPARTMENT STORES	40 lbs./100 sq. ft.
	SUPERMARKETS	9 lbs./100 sq. ft.
	RESTAURANTS	1.7 lbs./Meal
	DRUG STORES	6 lbs./100 sq. ft.
INDUSTRIAL	WAREHOUSES	1.7 lbs./sq. ft.
HOTELS, ETC.	HOTELS - MEDIUM CLASS	1,6 lbs./room plus 1.3 lbs./meal
	MOTELS	1.8 lbs./room
	TRAILER CAMPS	7 lbs./trailer
SCHOOLS	GRADE	10 lbs./room plus .25 lbs./pupil
	HIGH SCHOOLS	8 lbs./room plus .25 lbs./pupil
INSTITUTIONS	HOSPITALS	8 lbs./bed
	NURSING HOMES	3 lbs./bed
	HOMES FOR AGED	3 lbs./bed
	REST HOMES	3 lbs./bed
PARKS AND RECREATION AREAS	CAMPGROUNDS	1.00 lbs./camper
	FAMILY PICNIC AREAS	.93 lbs./picnicker
	DAY USE FACILITY	.05 lbs./user
	ORGANIZED CAMPS	1.8 lbs./occupant
	RESORT RESTAURANTS	.8 lbs./meal
	OVERNIGHT LODGES	1.87 lbs./visitor
	WINTER SPORTS AREAS	1.87 lbs./visitor
	DAYLODGE, WINTER SPORTS	2.9 lbs./visitor
	LODGES WITH KITCHENS	.6 lbs./occupant
	RESORTS	3.4 lbs. per capita
	SEASONAL HOMES	2.5 lbs. per capita
	CONCESSION STAND	.015 lbs./patron

* AVERAGES 65 lbs./week/home (URBAN)
AVERAGE 41 lbs./week/home (RURAL)

5.2 COMMON TERMINOLOGY USED IN SOLID WASTE SYSTEMS

AIR POLLUTION	The presence of contaminants in the air to such a degree that the normal self-cleansing or dispersive ability of the atmosphere cannot cope with them.
ALLEY COLLECTION	The collection of refuse placed adjacent to the alley by the collection crew. The collection is usually at the property line.
BACKYARD COLLECTION	The collection of refuse within the generator's property usually located at the rear of the building.
BALER	A machine used to compress and bind solid waste or other materials.
BOX	Cardboard, paper, wood, etc., used to contain refuse and normally intended to be disposed of along with the contents.
BUNDLE	Prepared garden trimmings, tied paper, or other similar material placed out for collection.
CAN	Conventional metallic, fiberboard or other reuseable refuse container fitted with handle and a lid.
CHARGING CHUTE	A passage through which waste materials are charged into an incinerator or compactor from above by gravity.
COLLECTION	The act of picking up refuse at home, business or industrial sites and putting it in the collection truck. Collection can be manual or mechanical.
COLLECTION FREQUENCY	Expresses the number of times per week that the collection activity takes place.
COLLECTION STOP	Stop made by the collection vehicle and crew on the route to collect refuse from one or more service stops.
COLLECTION COST PER TON	Average cost per ton of refuse collected including labor and equipment costs.
COLLECTION DAY	The particular day of the week that the collection agency provides the collection service.
COLLECTION ROUTE	The route the individual collection truck travels.
COLLECTION TIME	Elapsed or cumulative time spent by the refuse collection crew in collecting refuse from a collection stop. Does not include travel time between collection stops on the route.
COMPACTOR	A machine that reduces refuse in bulk by compression.
CONTAINER	Can, box, or disposable container used for storage of refuse. Includes both household and commercial types.
CONTAINER LOCATION	The location of the storage container which holds the refuse prior to the collection activity.
CREW SIZE	Number of persons assigned to each refuse collection vehicle, including the driver.
CURBSIDE COLLECTION	The collection of refuse placed by the generator at the curb location by the collection crew.

DIRECT HAUL	The transporting of collected wastes by the collection vehicle. In some cases the direct haul is by the waste generator.
DISPOSABLE CONTAINER	Plastic, paper, cardboard, or other container for refuse intended for disposal along with its contents.
DISPOSAL COST PER TON	The cost of landfilling a ton of waste material. Usually arrived at by dividing the cost of operations by the tons of waste the site handles in a given period of time.
FREQUENCY	The number of times a given event occurs; expressed as a percentage of all recorded occurrences.
HAUL DISTANCE	(a) Distance collection truck must travel from its last collection stop to the sanitary landfill or transfer site. (b) Distance transfer vehicle must travel from the intermediate waste storage area to the sanitary landfill.
HAUL TIME	Elapsed or cumulative time spent hauling collected refuse from the route or transfer site to the disposal point.
LEVEL OF SERVICE	Extent of refuse collection service provided to the recipient, including collection frequency, material collected, storage location, pre-preparation, and other factors.
LITTER	Highly visible portion of solid waste which is carelesslly discarded by means other than regular disposal systems.
MAN-MINUTES PER TON	Total labor minutes expended per ton of refuse collected. Route man-minutes per ton refers to only the portion of total labor time expended while the crew is on the route.
OPEN DUMP	The consolidation of waste from one or more sources at a central disposal site which has little or no management.
POLLUTION	Contamination in a physical sense.
SERVICE STOP	Residence, commercial establishment, or other living or business unit receiving periodic refuse collection service.
SOLID WASTE MGMT.	The purposeful systematic control of the storage, collection, transportation, processing and final disposal of solid waste.
STATIONARY COMPACTOR	An adjunct of a refuse container system which compacts refuse at the site of generation.
STORAGE LOCATION	Location at which refuse is stored prior to collection.
TOTAL ITEMS	Total number of containers and bundles at the service stop.
TRAVEL TIME	The elapsed or cumulative time of travel between collection stops on the route.
TRUCK CAPACITY	Volumetric capacity for refuse.
WASTE GENERATOR	The original generator of the waste, may be a private residence, a business location etc.
WASTE HANDLING	The manipulation or transportation of waste.

5.3 CONVERSION DATA

The design and development of refuse handling equipment and in turn the common language used in describing truck capacities, storage container sizes, etc. of various equipment types has been influenced by our American neighbors. To a great extent this is due to the fact that the majority of refuse equipment presently in use throughout Western Canada has either been directly imported from the United States or was manufactured in Canada under a licensed agreement with a United States equipment developer. Consequently, measurements relating to the entire solid waste management industry remain in standard English units. Approximate measurement figures which are useful in comparing many solid waste storage and collection items are presented in the following pages. The date is set out in the standard English units along with the appropriate metric conversion. In addition a simplified method of converting most measurements encountered in the industry from English to metric has been included.

A standard household garbage can holds,	2.5 cu. ft. or .07 cu. meters
Eleven household garbage cans equal,	1.0 cu. yd. or .8 cu. meters
Standard plastic household garbage bags hold,	2.8 cu ft. or .08 cu. meters
Ten household garbage bags equal,	1.0 cu. yd. or .8 cu. meters
Standard steel drums used for burning hold,	6 cu. ft. or .17 cu. meters
4½ Standard steel drums equal,	1 cu. yd. or .8 cu. meters
Front end, rear end and side loader containers normally hold,	2.0 cu. yds. or 1.5 cu. meters
	3.0 cu. yds. or 2.3 cu. meters
	4.0 cu. yds. or 3.0 cu. meters
	6.0 cu. yds. or 4.6 cu. meters
	8.0 cu. yds. or 6.0 cu. meters
Standard roll-off containers hold,	30.0 cu. yds. or 28 cu. meters
	40.0 cu. yds. or 31 cu. meters
	50.0 cu. yds. or 38 cu. meters
1 cu. yd. of loose dry household waste,	130-180 lbs. or 60-82 kg.
1 cu. yd. of loose wet household waste,	350-520 lbs. or 159-236 kg.
1 cu. yd. compacted dry refuse	600-850 lbs. or 272-386 kg.
1 cu. yd. compacted wet refuse	800-1100 lbs. or 363-499 kg.
1 cu. yd. baled refuse	2100 lbs. or 953 kg.
1 cu. yd. shredded refuse	420 lbs. or 190 kg.
1 cu. yd. ashes	650-800 lbs. or 295-363 kg.
1 cu. yd. clay brick	3200 lbs. or 1450 kg.
1 cu. yd. gravel	3000 lbs. or 1362 kg.
1 cu. yd. loose dirt	2400 lbs. or 1090 kg.
Box of a standard halfton	68 cu. ft. or 2.5 cu. yds
	2.5 cu. yds. or 1.9 cu. meters
Haul All #12	12.0 cu. yds. or 9 cu. meters
Rear end loaders, standard	16.0 cu. yds. or 12 cu. meters
	20.0 cu. yds. or 15 cu. meters
	25.0 cu. yds. or 19 cu. meters
Shupak Side Loader	25.0 cu. yds. or 19 cu. meters
Front end loaders	30.0 cu. yds. or 23 cu. meters
	33.0 cu. yds. or 25 cu. meters
Hopper capacity, rear end loaders	1.5-3.0 cu. yds. or 1.1-2.3 cu. meters
Live bottom transfer trailers	97-112 cu. yds. or 74-86 cu. meters
Compaction transfer trailers	65-75 cu. yds. or 50-57 cu. meters

Common Conversions

Multiply	By	To Obtain
Acres	0.405	Hectares
Acres	43560	Square feet
Acres	4047	Square meters
Acres	0.0016	Square miles
Cubic feet	0.0283	Cubic meters
Cubic feet	7.4805	Gallons
Cubic feet	28.32	Liters
Cubic meters	35.31	Cubic feet
Cubic meters	1.308	Cubic yards
Cubic meters	264.2	Gallons
Cubic meters	1000	Liters
Cubic yards	27	Cubic feet
Cubic yards	0.7645	Cubic meters
Cubic yards	202.0	Gallons
Cubic yards	764.5	Liters
Feet	0.3048	Meters
Feet	0.3333	Yards
Gallons	0.1337	Cubic feet
Gallons	0.0038	Cubic meters
Gallons	3.785	Liters
Hectares	2.471	Acres
Kilometers	0.6214	Miles
Liters	0.0353	Cubic feet
Litres	0.0010	Cubic meters
Liters	0.2642	Gallons
Meters	3.281	Feet
Miles	5280	Feet
Miles	1.609	Kilometers
Miles	1760	Yards
Ounces (avdp)	28.35	Grams
Pounds (avdp)	0.454	Kilograms
Square feet	0.0929	Square meters
Square kilometers	0.3861	Square miles
Square meters	10.76	Square feet
Square meters	1.1960	Square yards
Square miles	640	Acres
Square miles	2.590	Square kilometers
Square yards	9	Square feet
Square yards	0.8361	Square meters
Tons (metric)	1000	Kilograms
Tons (metric)	2205	Pounds
Tons (short)	2000	Pounds
Tons (short)	0.9072	Tons (metric)
Yards	3	Feet
Yards	0.9144	Meters